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North et al.

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(54) **LEAD IDENTIFICATION SYSTEM**

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A61N 1/05 (2006.01)

(52) **U.S. Cl.**
USPC **607/116**; 607/117

(58) **Field of Classification Search**
USPC 607/115–119
See application file for complete search history.

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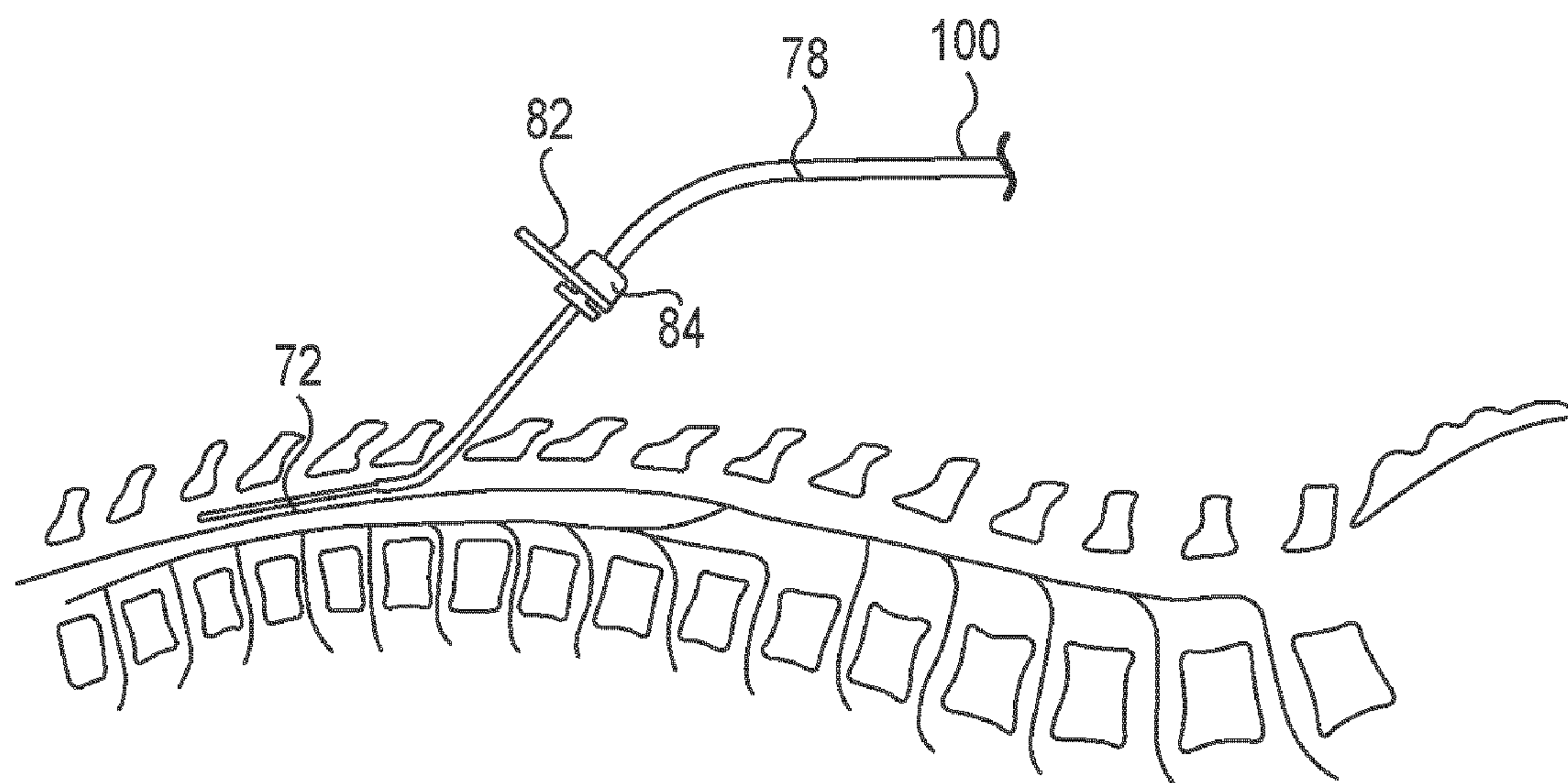
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(57) **ABSTRACT**

A lead identification system for tracking a plurality of neurostimulation leads during implantation in a patient, and a method of using the same. The lead identification system includes a plurality of lead indicators each adapted to attach to one of a plurality of epidural needles to identify the leads. At least one clip adapted to releasably attach to proximal ends of the leads is provided with corresponding lead indicators. The trial cable for conducting trial stimulation includes connectors with corresponding lead indicators. A plurality of lead indicator stylets are provided for insertion into lumens at the proximal ends of the leads. The pulse generator also has connectors with corresponding lead indicators. The various lead indicators permit a surgeon to track a particular lead to the corresponding connectors on the pulse generator.

24 Claims, 14 Drawing Sheets



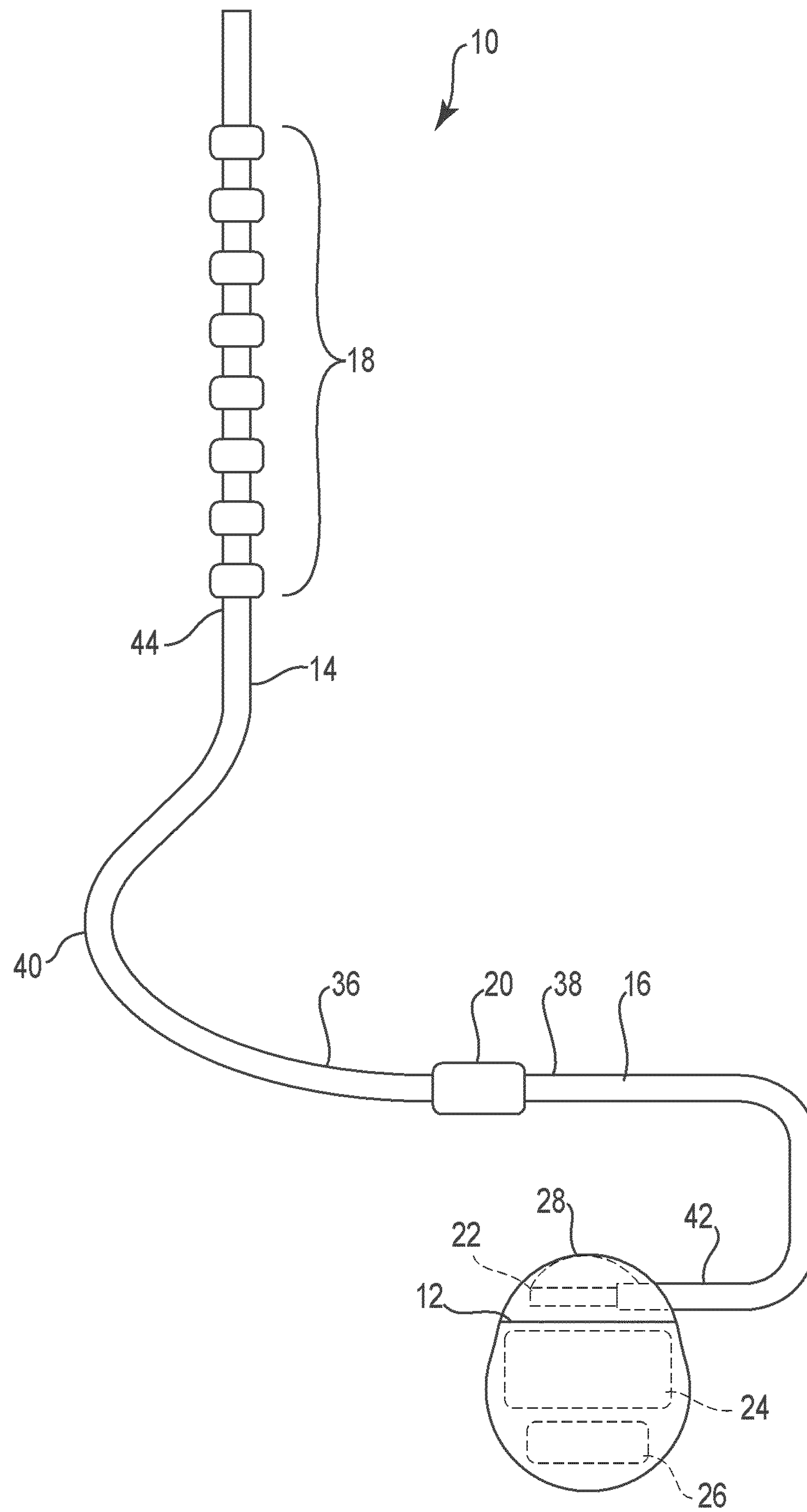


Fig. 1

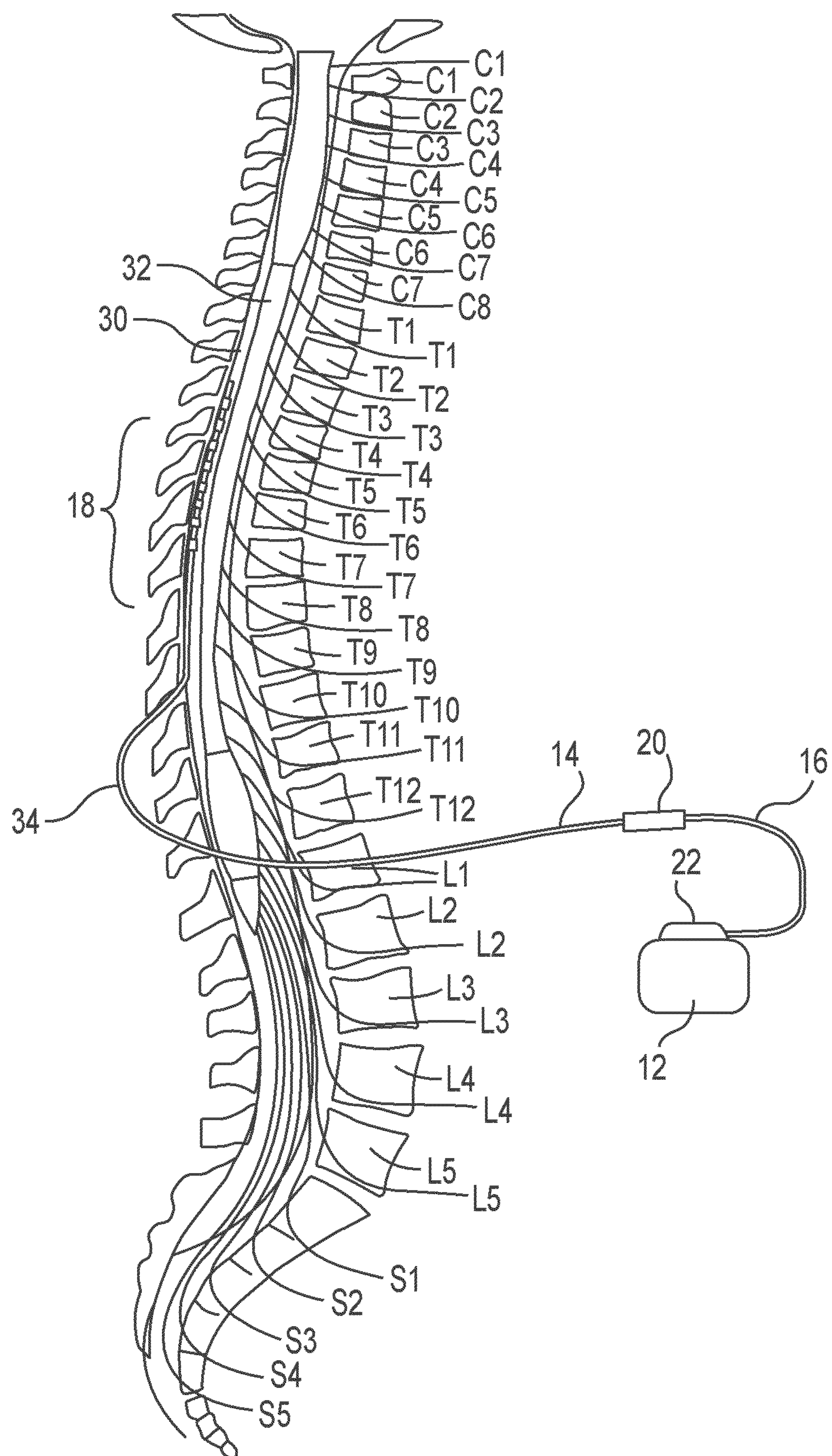


Fig. 2

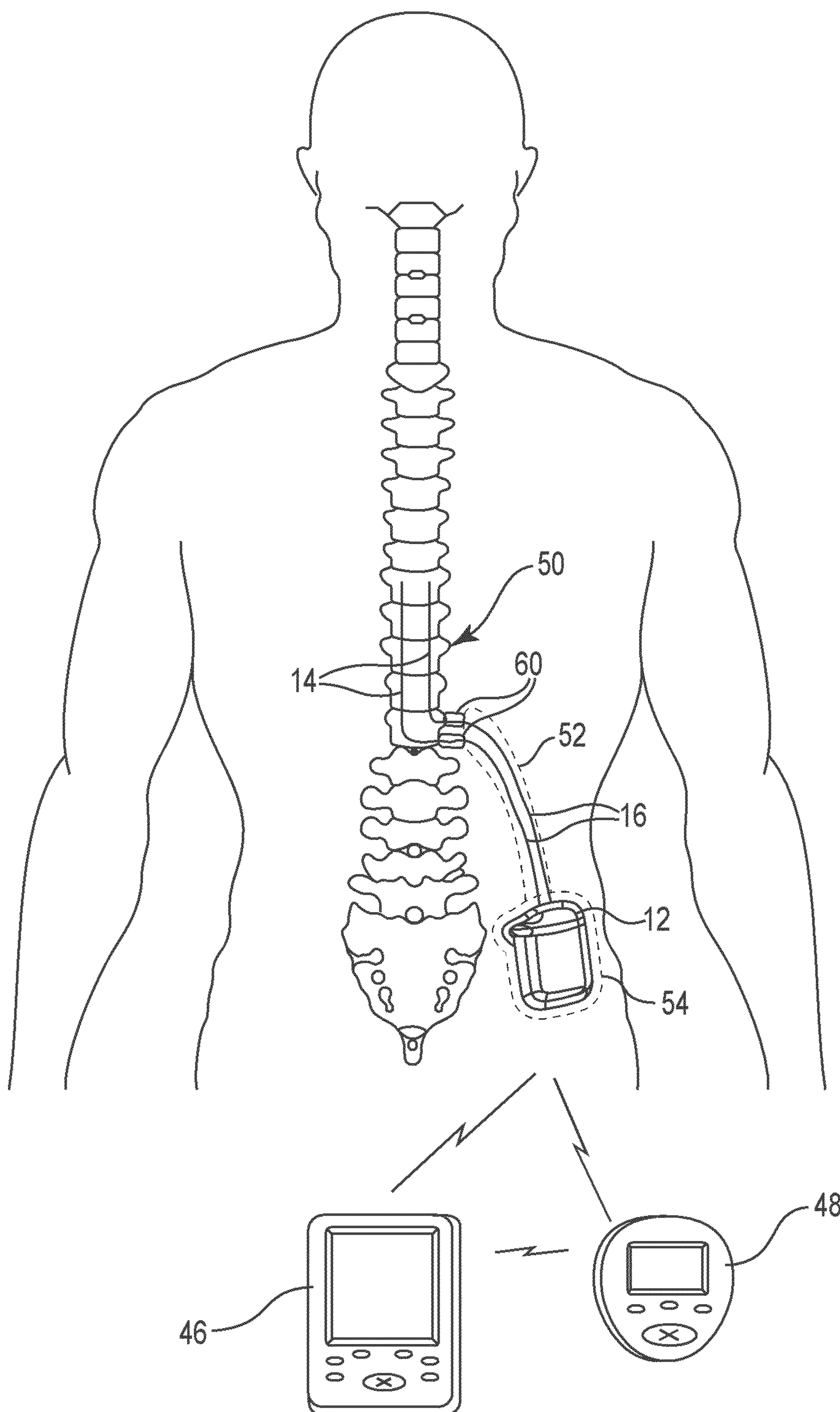


Fig. 3

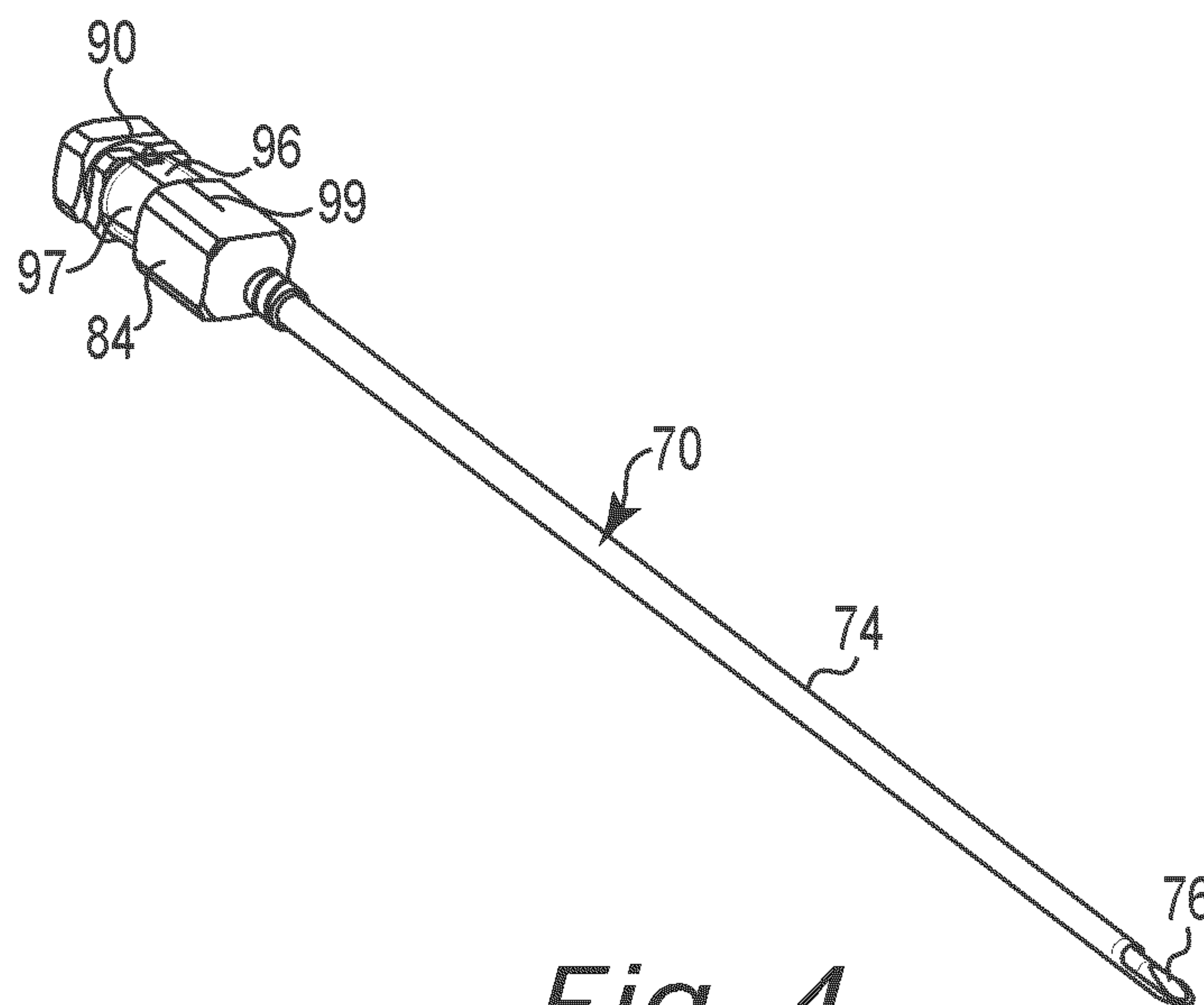


Fig. 4

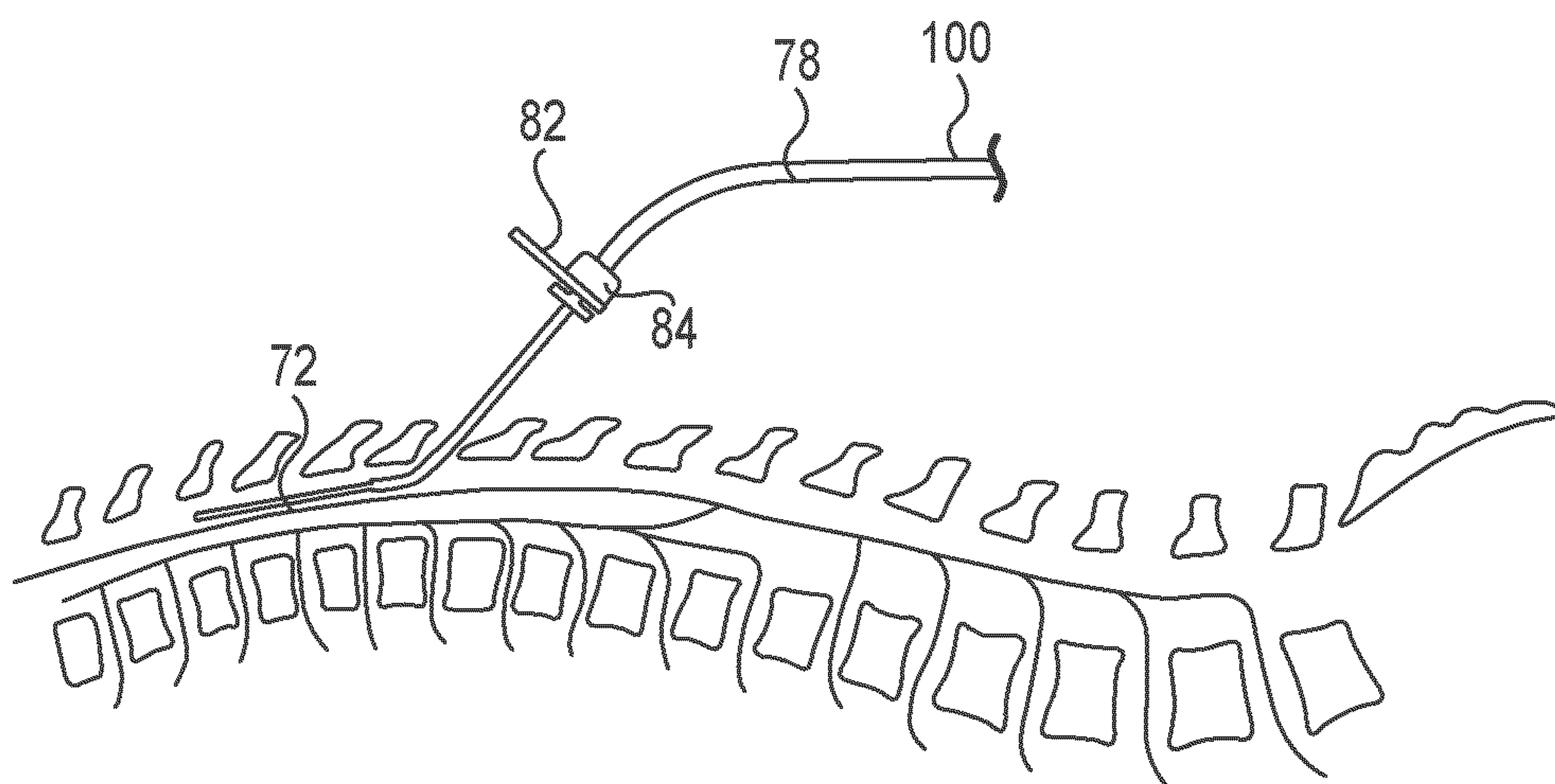


Fig. 5

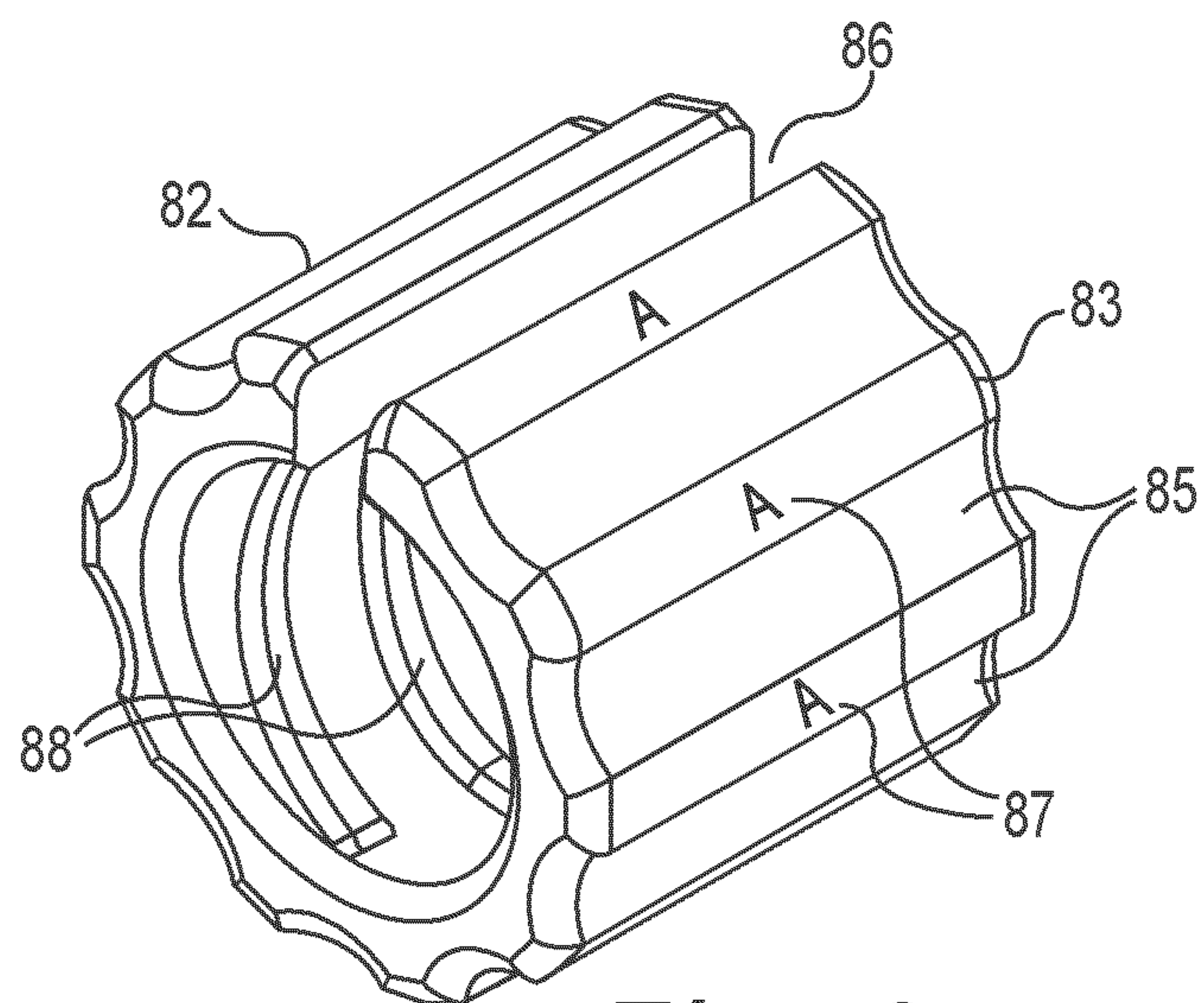


Fig. 6

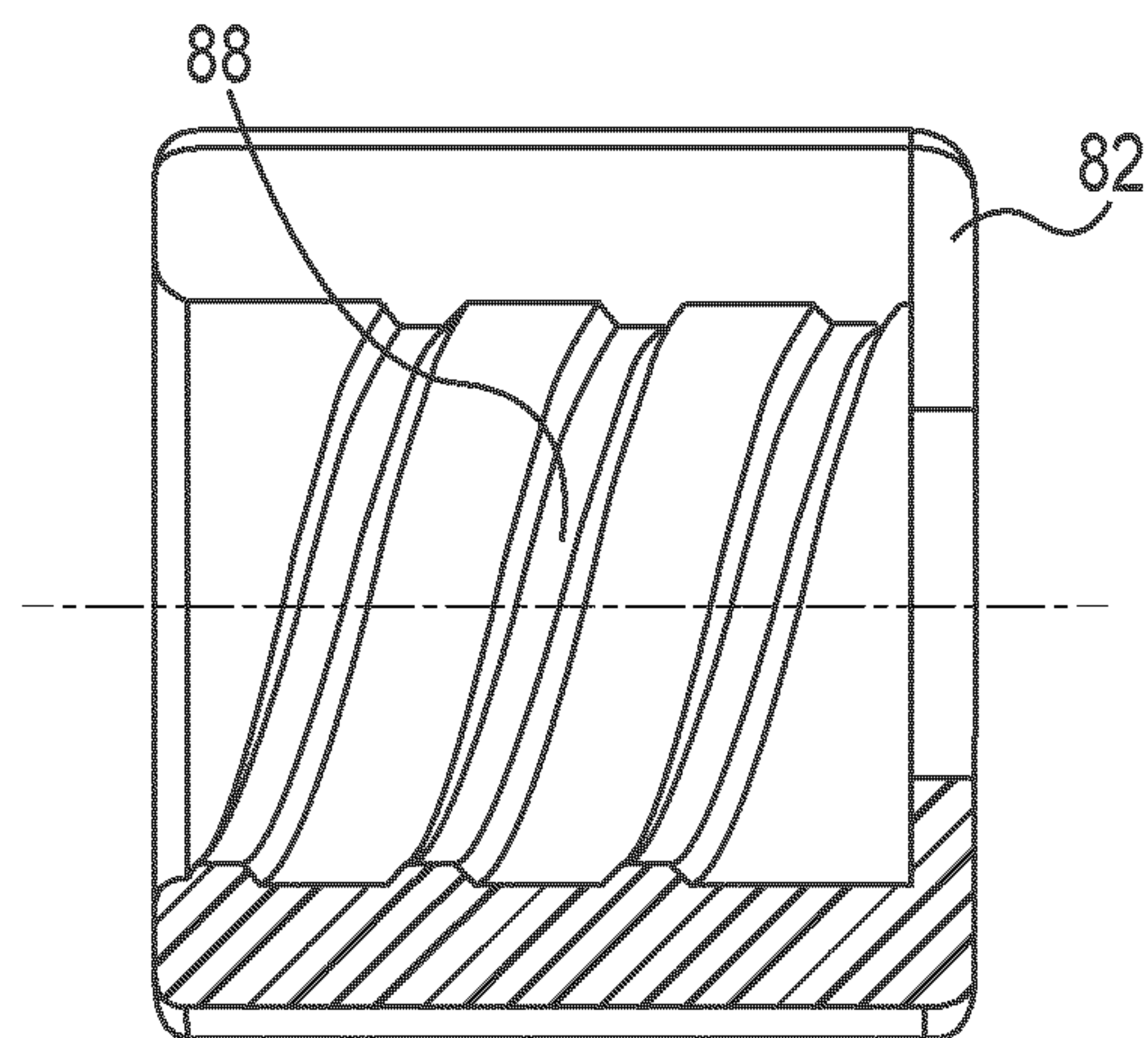


Fig. 7

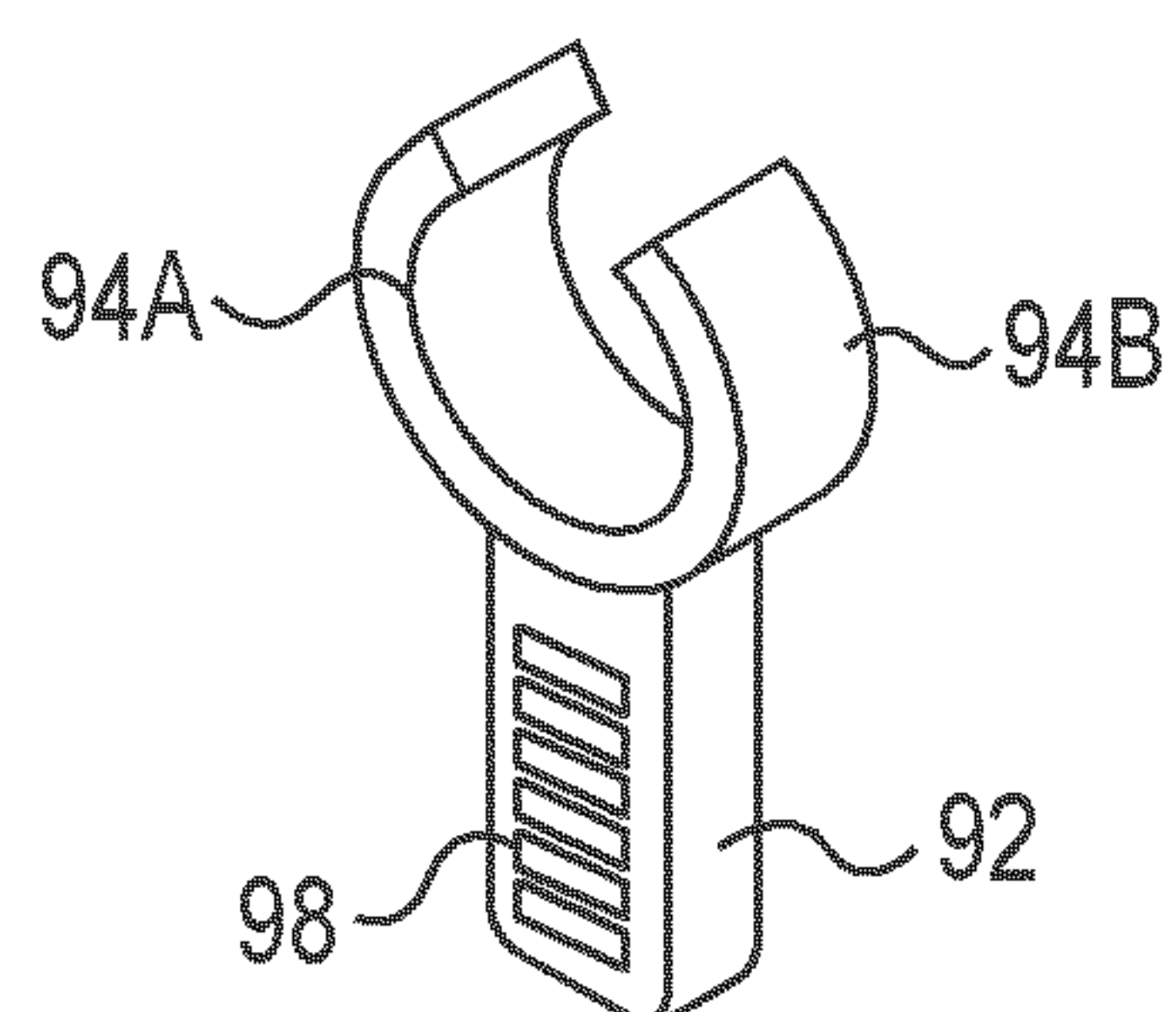


Fig. 8

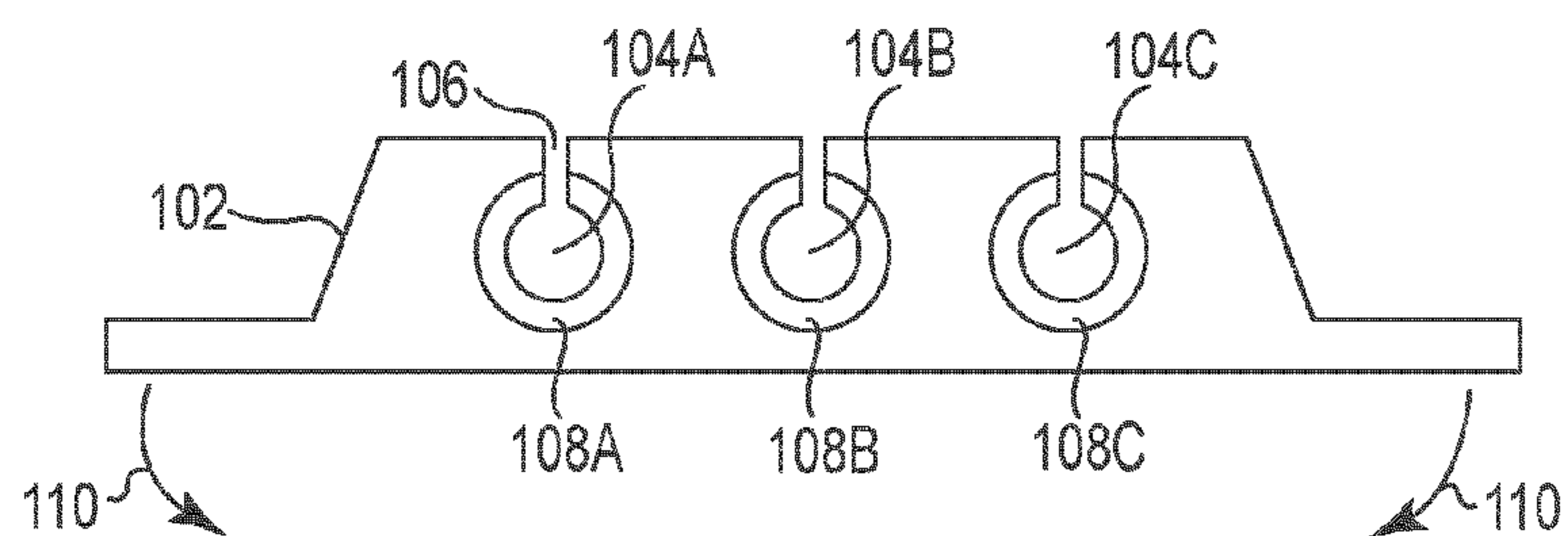


Fig. 9

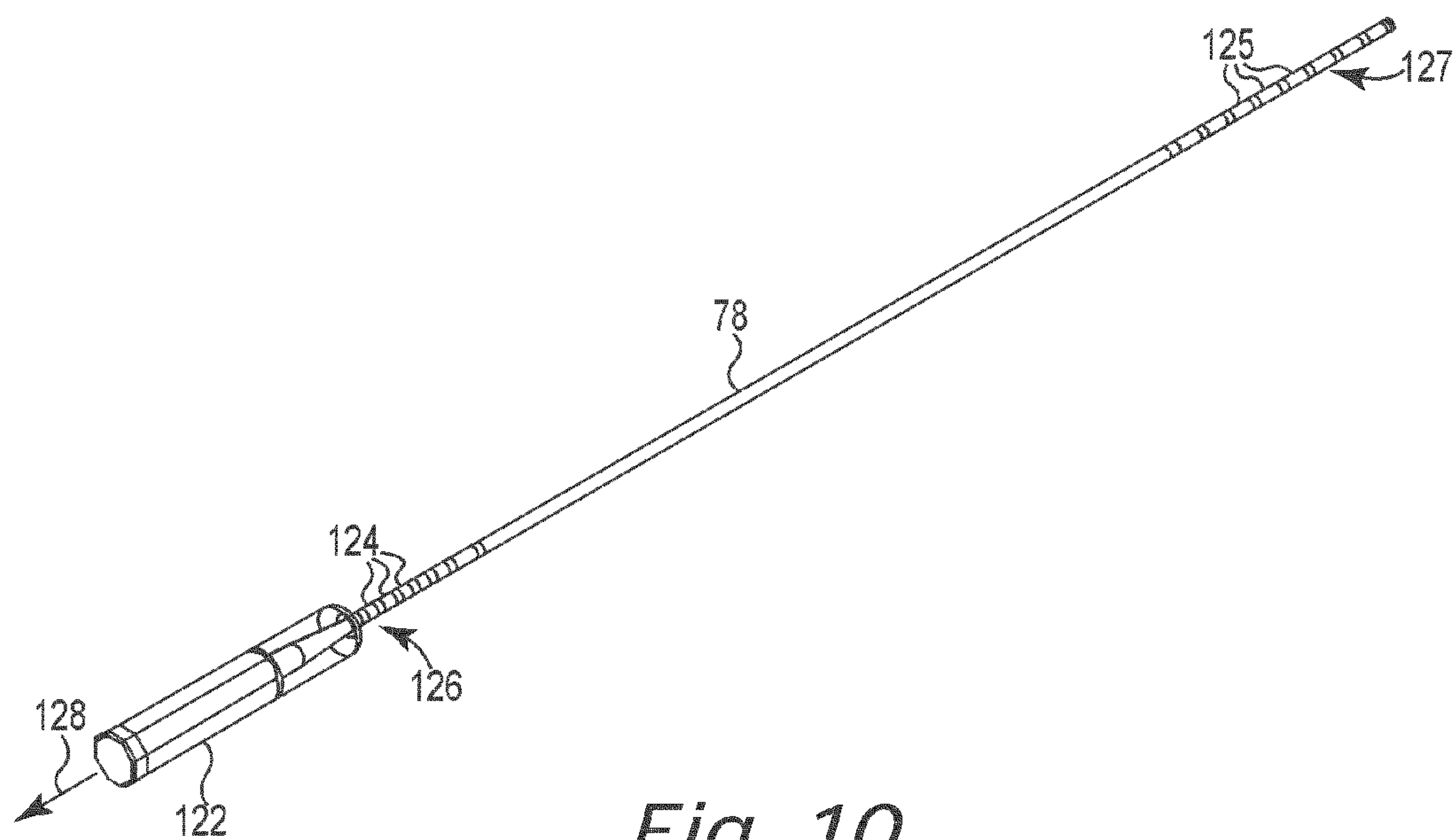


Fig. 10

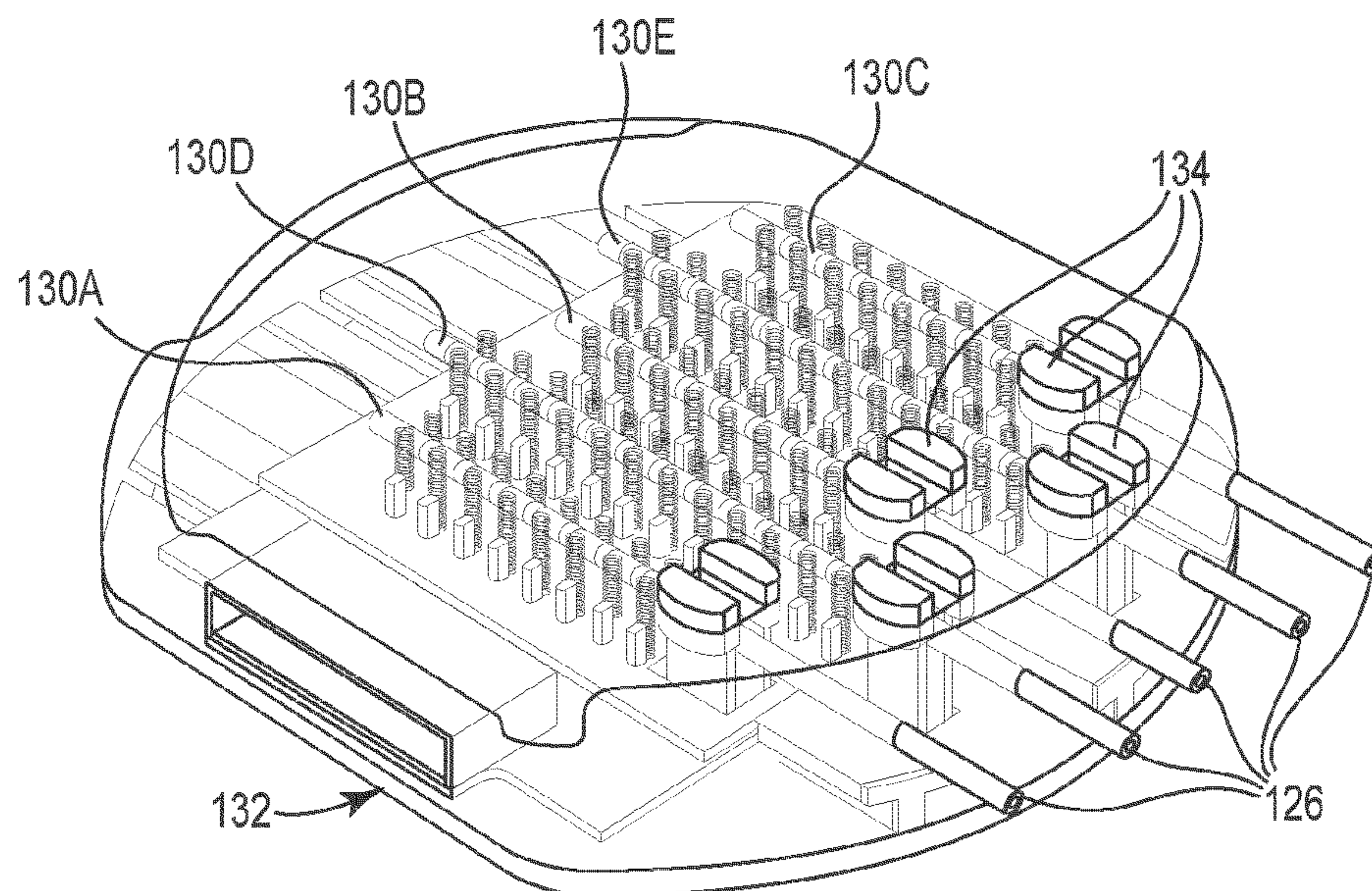


Fig. 11

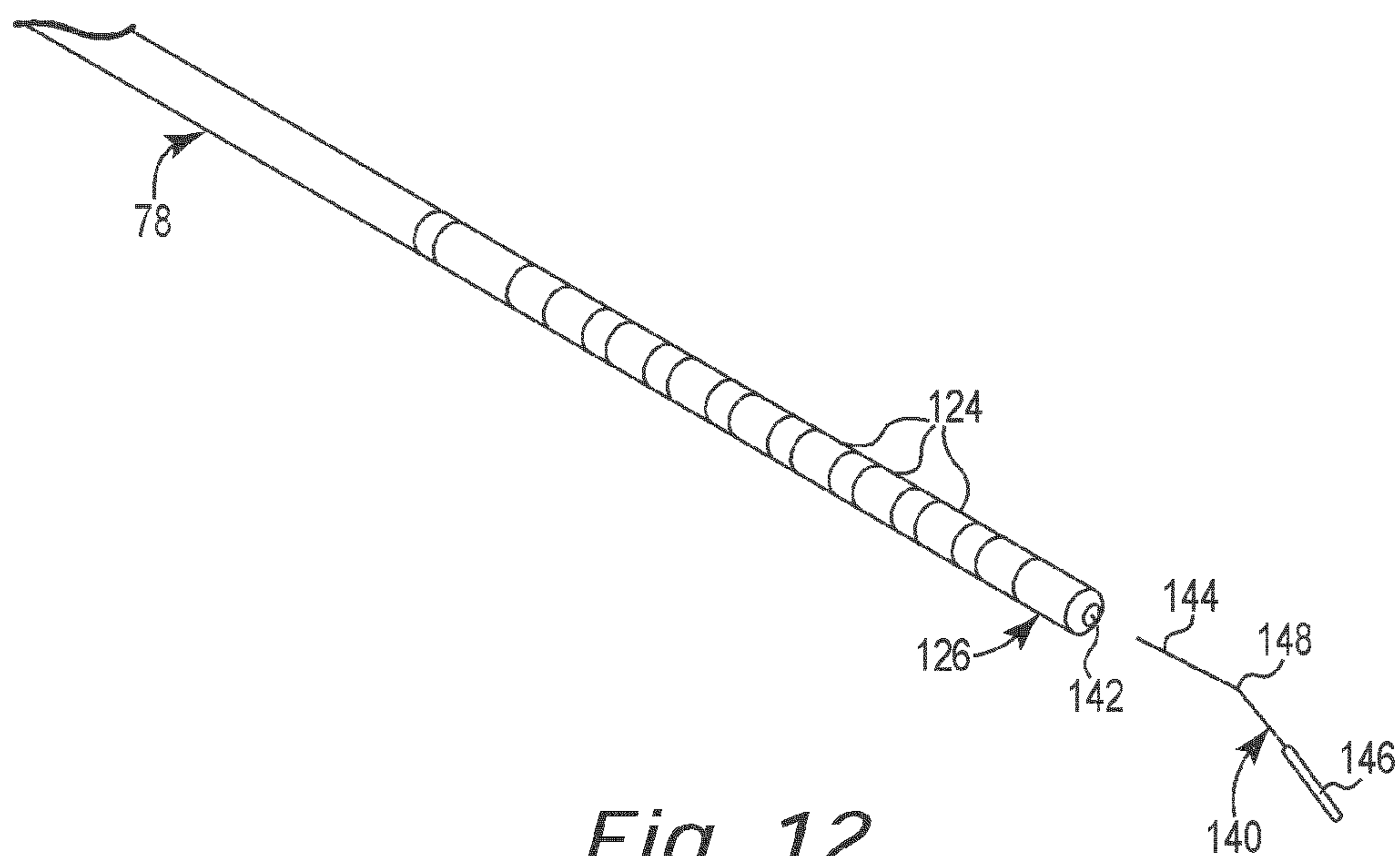


Fig. 12

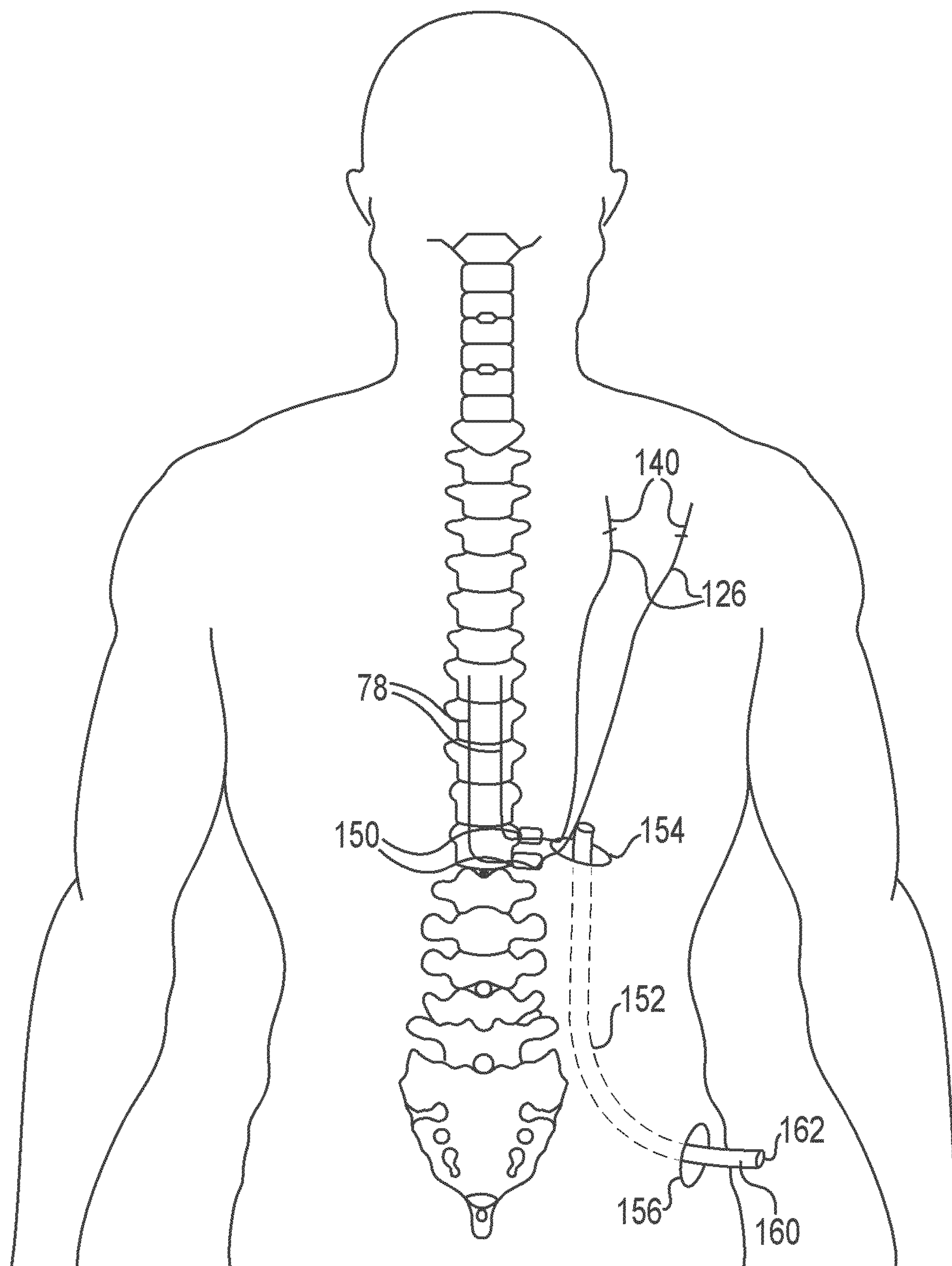
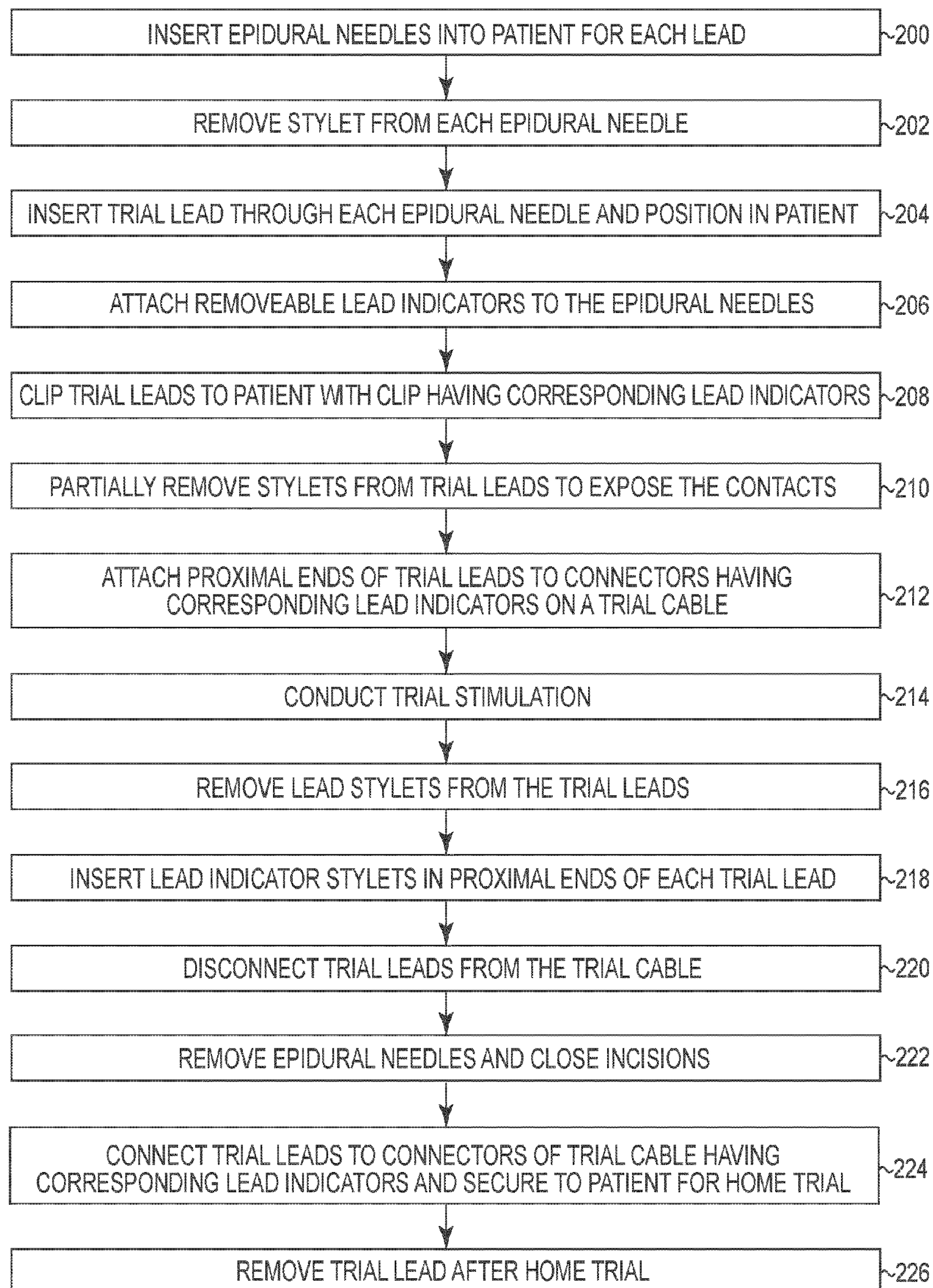
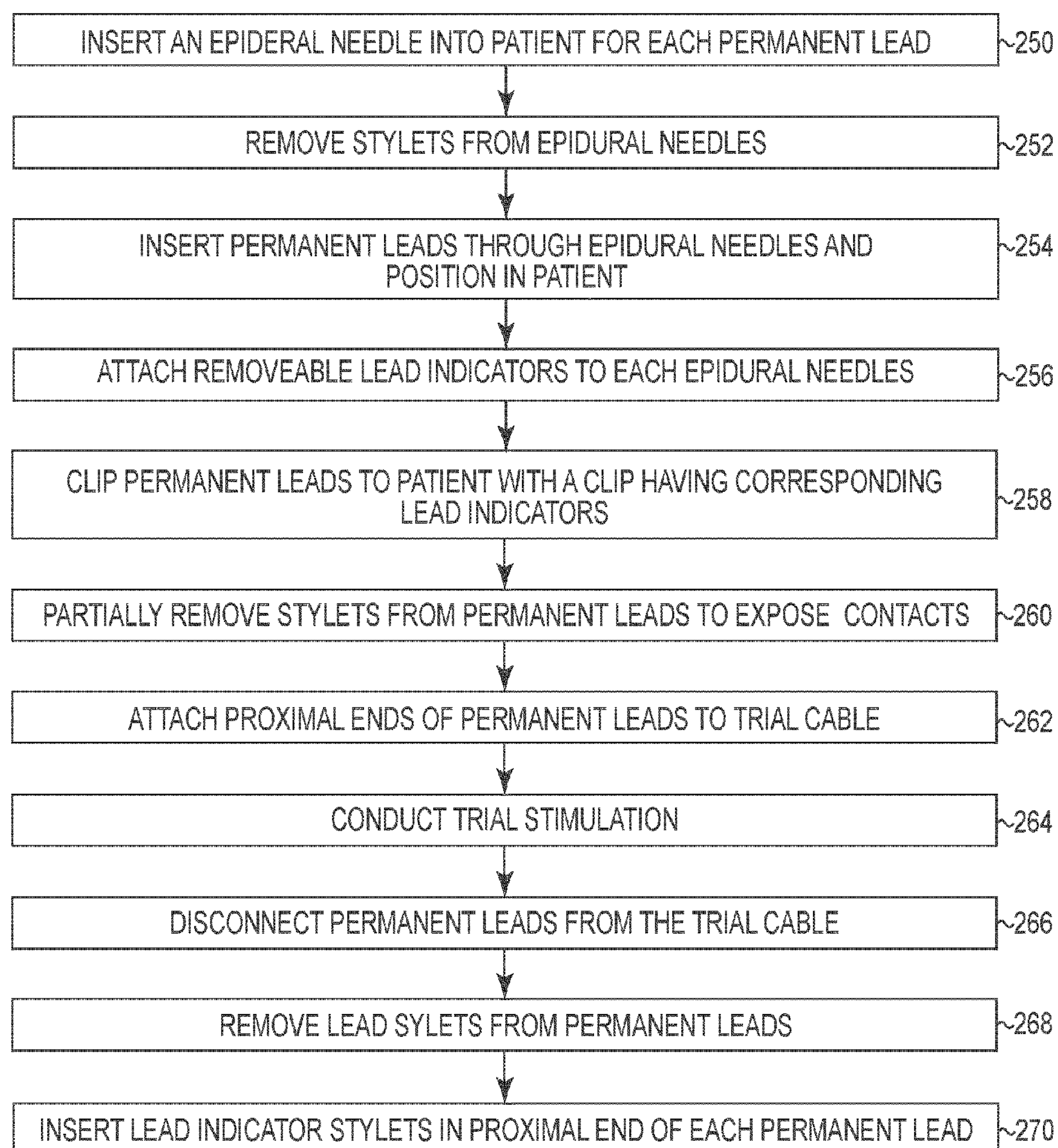
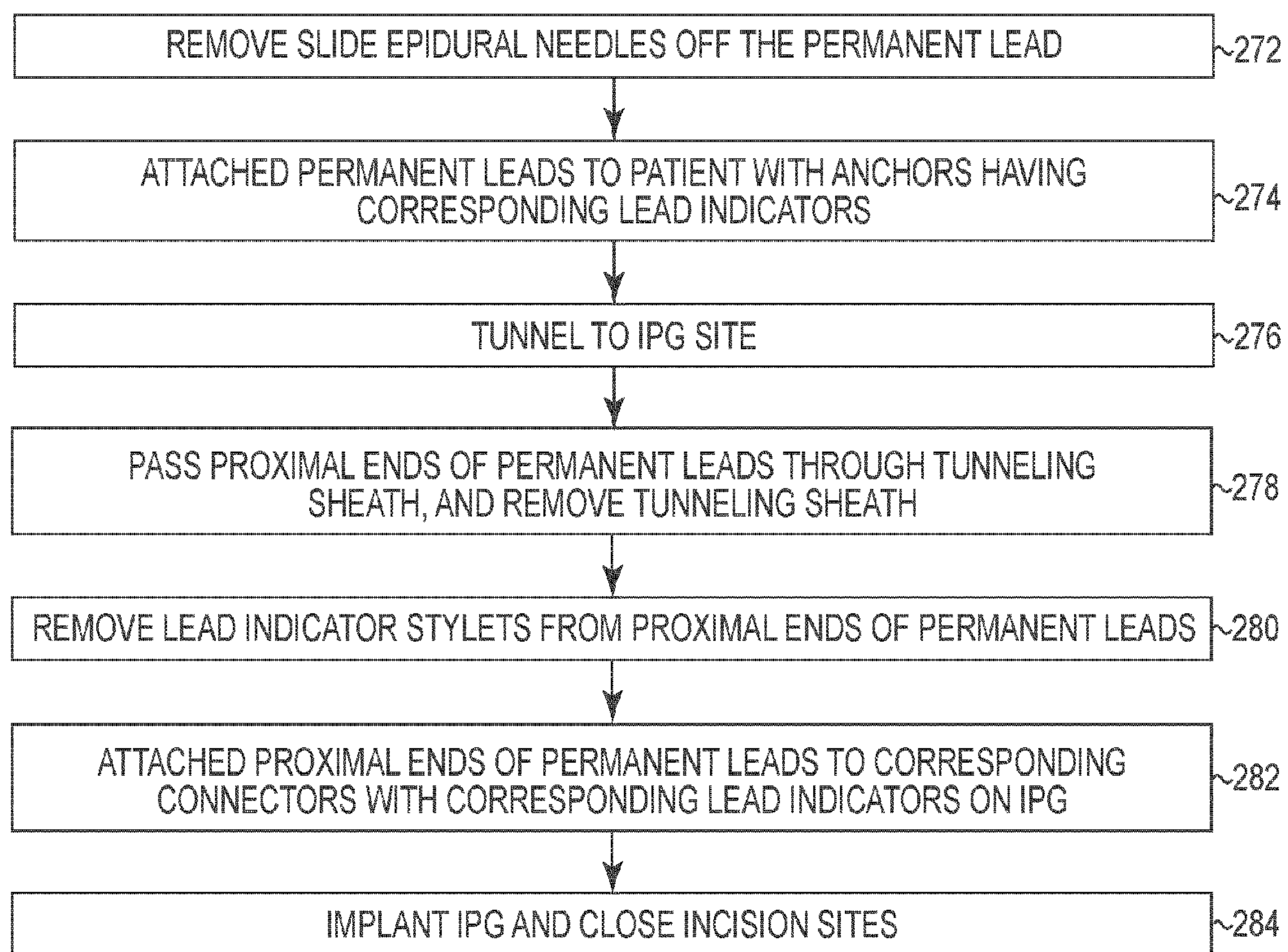
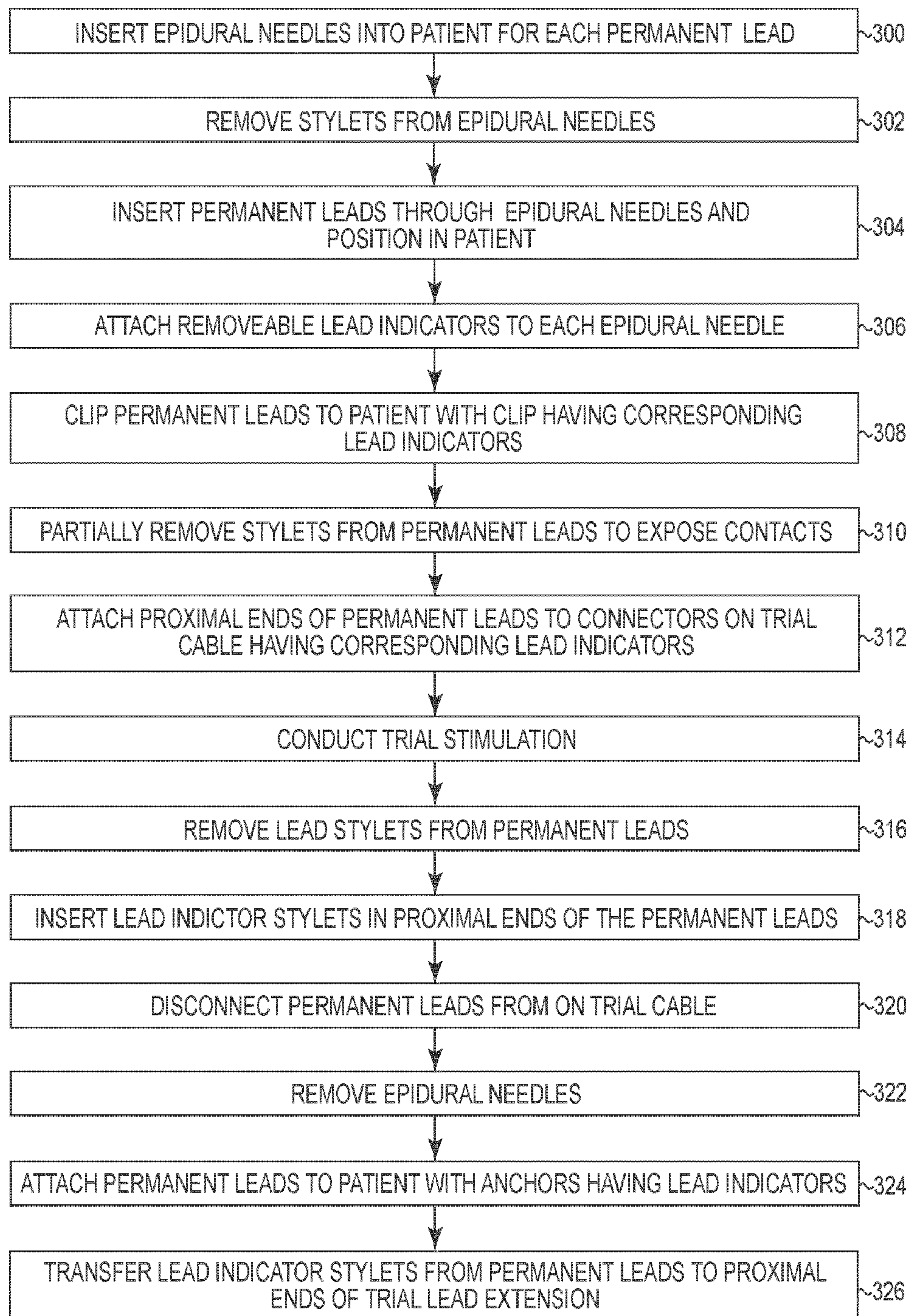


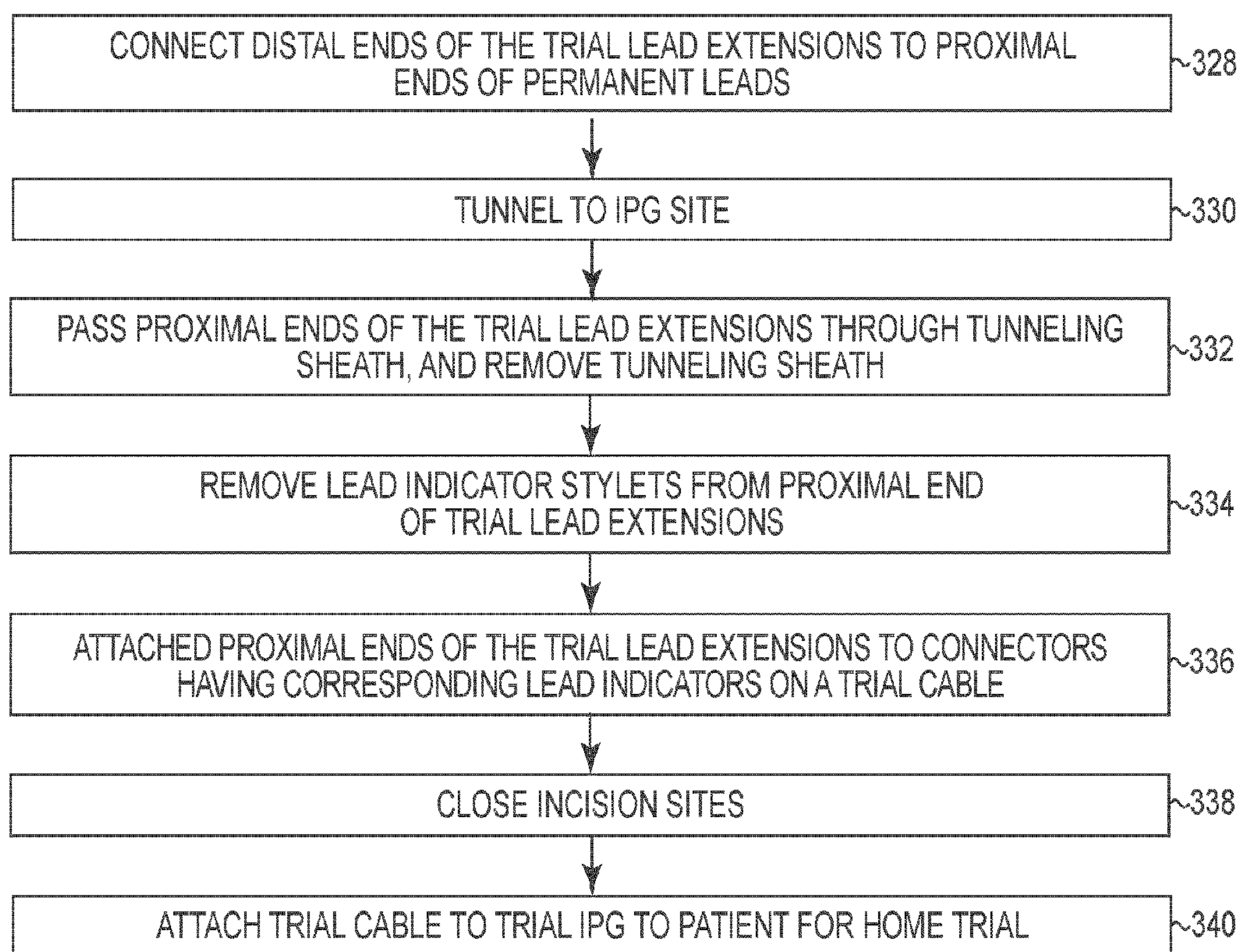
Fig. 13

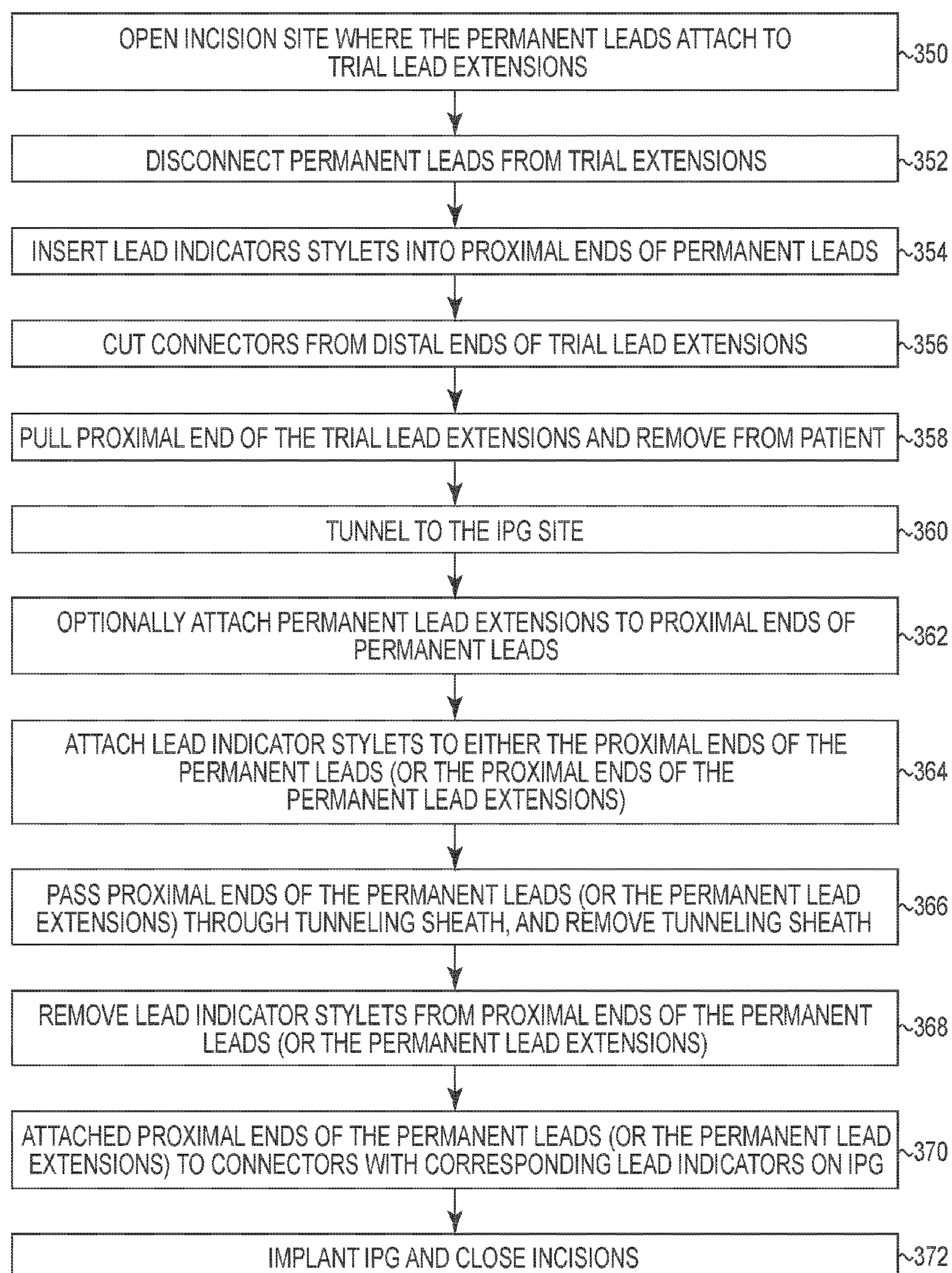
*Fig. 14*

*Fig. 15A*

*Fig. 15B*

*Fig. 16A*

*Fig. 16B*

*Fig. 16C*

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LEAD IDENTIFICATION SYSTEM

FIELD

The present disclosure relates to a lead identification system for multiple neurostimulation leads during implantation within a living body.

BACKGROUND

Implantable neurostimulation systems have proven therapeutic in a wide variety of diseases and disorders. These implantable neurostimulation systems typically include one or more stimulation leads implanted at the desired stimulation site and an implantable neurostimulator, such as an implantable pulse generator (IPG), implanted remotely from the stimulation site, but coupled either directly to the stimulation leads or indirectly to the stimulation leads via one or more lead extensions in cases where the length of the stimulation leads is insufficient to reach the IPG.

In the context of an SCS procedure, one or more stimulation leads are introduced through the patient's back into the epidural space under fluoroscopy, such that the electrodes carried by the leads are arranged in a desired pattern and spacing to create an electrode array. After proper placement of the stimulation leads at the target area of the spinal cord, the leads are anchored in place at an exit site to prevent movement of the stimulation leads. Whether lead extensions are used or not, the proximal ends of the stimulation leads exiting the spinal column are passed through a tunnel subcutaneously formed along the torso of the patient to a subcutaneous pocket (typically made in the patient's abdominal or buttock area) where a neurostimulator is implanted.

The stimulation leads are then connected directly to the neurostimulator by inserting the proximal ends of the stimulation leads within one or more connector ports of the IPG or connected to lead extensions, which are then inserted into the connector ports of the IPG. The IPG can then be operated to generate electrical pulses that are delivered, through the electrodes, to the targeted tissue, and in particular, the dorsal column and dorsal root fibers within the spinal cord.

Oftentimes, multiple lead bodies may extend from the spinal region of the patient. For example, multiple percutaneous leads may be implanted within the patient adjacent the spinal cord, or in the case of paddle leads, multiple lead tails may extend from the paddle, with each lead tail being coupled to specific electrodes on the paddle. Because the programming of the IPG will depend upon the physical locations of the electrodes relative to the patient's spinal cord, the proximal ends of the lead bodies are labeled before passing them through the tunneling straw, so that the surgeon can keep track of which set of electrodes is connected to which connector port on the implanted IPG (which may include up to four ports in the near future), or if multiple IPGs are to be implanted, which set of electrodes is connected to which IPG.

One technique used by surgeons to identify the lead bodies is to tie sutures around the proximal ends of the lead bodies prior to introducing them through the tunneling straw; for example, one suture around a first lead body, two sutures around a second lead body, three sutures around a third lead body, etc. Once the proximal ends of the lead bodies exit the tunneling straw, the surgeon can then identify each lead body (and thus the corresponding electrodes) by the number of sutures tied to the respective lead body, thereby allowing the lead body to be connected to the correct port on the IPG.

While this technique can be successfully employed to identify lead bodies, it considerably extends the length of the

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surgery time, which is undesirable. In some cases, the identification features, such as different colors or markings, can be incorporated into the proximal ends of the lead bodies, such that the lead bodies can be identified as they exit the tunneling straw. If the lead bodies are inserted into the incorrect connector ports, intra-operative testing of the lead placement may be compromised. Additional surgical time may be wasted to identify and correct the connection problem. If the errors remain unidentified, the patient may leave the operating room with the lead bodies incorrectly connected. During post-operative fitting, additional time may then be lost identifying and compensating for lead bodies that are not in the proper connector ports. This ultimately can result in sub-optimal therapy.

BRIEF SUMMARY

The present disclosure relates to a lead identification system for multiple neurostimulation leads that permits the surgeon to track electrodes on a particular lead to the correct connectors on the implantable pulse generator.

The present lead identification system provides corresponding lead indicators that permit the surgeon to track the electrodes of a particular therapy delivery element to the correct connectors on an implantable pulse generator. The lead indicators are preferably releasably attachable to the components of the neurostimulation system and can be shifted or reconfigured by the surgeon during the procedure. Consequently, the components of the neurostimulation system, such as the epidural needles, the leads and lead extensions, lead clips, lead anchors, stylets, internal and external pulse generators, and trial cables can all be generic without any labels or indicia. The use of removable lead indicators dramatically reduces the inventory of components for the neurostimulation system.

One embodiment is directed to a method of implanting a plurality of trial neurostimulation leads in a patient. An epidural needle is inserted into the patient for each trial lead. A trial lead is inserted through each epidural needle and positioned in the patient. A removable lead indicator is attached to each epidural needle. Proximal portions of the trial leads are attached to a clip with corresponding lead indicators. The proximal ends of the trial leads are electrically coupled to connectors having corresponding lead indicators on the trial cable. Trial stimulation of the trial leads is conducted to confirm lead placement. Corresponding lead indicator stylets are inserted in lumens of each of trial lead. The trial leads are disconnected from the trial cable. The epidural needles are removed from the patient by sliding the epidural needles off the trial leads. The incisions around the trial leads are closed. The trial leads are electrically coupled to connectors having corresponding lead indicators on an external pulse generator. The neurostimulation leads are operated during a trial period.

The removable lead indicators can be one or more of color indicators, tactile indicators, alpha-numeric indicators, or a combination thereof.

The present disclosure is also directed to a method of implanting a plurality of permanent neurostimulation leads in a patient. An epidural needle is inserted into the patient for each permanent lead. A permanent lead is inserted through each epidural needle and positioned in the patient. A removable lead indicator is attached to each epidural needle. Proximal portions of the permanent leads are attached to a clip with corresponding lead indicators. The proximal ends of the permanent leads are electrically coupled to connectors having corresponding lead indicators on the trial cable. Trial stimulation of the permanent leads is conducted to confirm lead

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placement. Corresponding lead indicator stylets are inserted in lumens of each of permanent lead. The permanent leads are disconnected from the trial cable. The epidural needles are removed from the patient by sliding the epidural needles off the permanent leads. The permanent leads are attached to the patient using anchors having corresponding lead indicators. Proximal ends of the permanent leads with the corresponding lead indicator stylets are passed through one or more lumens to an implantable pulse generator located at a remote implantation site in the patient. The corresponding lead indicator stylets are removed from the lumens of the permanent leads. The proximal ends of the permanent leads are electrically coupled to connectors having corresponding lead indicators on an implantable pulse generator. The incision sites around the permanent leads and the implantable pulse generator are closed.

The present disclosure is also directed to a method of implanting a plurality of permanent neurostimulation leads with trial lead extensions in a patient. An epidural needle is inserted into the patient for each permanent lead. A permanent lead is inserted through each epidural needle and positioned in the patient. A removable lead indicator is attached to each epidural needle. Proximal portions of the permanent leads are attached to a clip with corresponding lead indicators. The proximal ends of the permanent leads are electrically coupled to connectors having corresponding lead indicators on a trial cable. A trial stimulation of the permanent leads is conducted to confirm lead placement. Corresponding lead indicator stylets are inserted in lumens of each of the permanent leads. The permanent leads are disconnected from the trial cable. The epidural needles are removed from the patient by sliding the epidural needles off the permanent leads. The permanent leads are attached to the patient using anchors having corresponding lead indicators. The removable lead indicator stylets are transferred from the permanent leads to lumens at proximal ends of the trial lead extensions. Distal ends of the trial lead extensions are attached to proximal ends of the corresponding permanent leads. Proximal ends of the trial lead extensions with the corresponding lead indicator stylets are passed through one or more lumens to a remote implantation site in the patient. The corresponding lead indicator stylets are removed from the lumens of the trial lead extensions. The trial leads are electrically coupled to connectors having corresponding lead indicators on an external pulse generator. Trial neurostimulation is conducted using the external pulse generator.

The present disclosure is also directed to a method of implanting a plurality of permanent neurostimulation leads without lead extensions in a patient. The incision site where trial lead extensions are connected to the permanent leads is opened. The permanent leads are disconnected from the trial lead extensions. Removable lead indicator stylets are inserted in lumens at proximal ends of the permanent leads. The trial lead extensions are removed from the patient. Proximal ends of the permanent leads with the corresponding lead indicator stylets are passed through one or more lumens to a remote implantation site in the patient. The corresponding lead indicator stylets are removed from the lumens of the permanent leads. The permanent leads are electrically coupled to connectors on an implantable pulse generator having corresponding lead indicators. The implantable pulse generator is sealed in the implantation site in the patient.

The present disclosure is also directed to a method of implanting a plurality of permanent neurostimulation leads with permanent lead extensions in a patient. The incision site where trial lead extensions are connected to the permanent leads is opened. The permanent leads are disconnected from

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the trial lead extensions. Removable lead indicator stylets are inserted in lumens at proximal ends of the permanent leads. The trial lead extensions are removed from the patient. The removable lead indicator stylets are transferred to lumens at proximal ends of the permanent lead extensions. Permanent lead extensions are attached to the permanent leads. The proximal ends of the permanent lead extensions with the corresponding lead indicator stylets are passed through one or more lumens to a remote implantation site in the patient. The corresponding lead indicator stylets are removed from the lumens of the permanent lead extensions. The permanent lead extensions are electrically coupled to connectors having corresponding lead indicators on an implantable pulse generator. The implantable pulse generator is sealed in the implantation site in the patient.

The present disclosure is also directed to a lead identification system for tracking a plurality of neurostimulation leads during implantation in a patient. The lead identification system includes a plurality of removable lead indicators each adapted to attach to one of a plurality of epidural needles to identify the leads. One embodiment includes rotating lead indicators attach to each of the epidural needles wherein a rotational orientation of the rotating lead indicators uniquely identify each of the therapy delivery elements. At least one clip adapted to releasably attach to proximal ends of the leads is provided with corresponding lead indicators. The trial cable for conducting trial stimulation includes connectors with corresponding lead indicators. A plurality of removable lead indicator stylets are provided for insertion into lumens at the proximal ends of the leads. A pulse generator is provided with connectors having corresponding lead indicators. The various removable lead indicators permit a surgeon to track electrodes on a particular lead to the corresponding connectors on the pulse generator.

The removable lead indicators can be one or more of color indicators, tactile indicators, alpha-numeric indicators, or a combination thereof. The leads can be trial leads or permanent leads. The pulse generator can be an external pulse generator for conducting trials or an implantable pulse generator. The lead identification system optionally includes one or more lead anchors adapted to attach the leads to the patient with corresponding lead indicators.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

FIG. 1 is a schematic illustration of a therapy delivery system.

FIG. 2 is a schematic illustration of an environment for a therapy delivery system in accordance with an embodiment of the present disclosure.

FIG. 3 is an alternate illustration of the environment for an implantable pulse generator with a therapy delivery element in accordance with an embodiment of the present disclosure.

FIG. 4 is a perspective view of epidural needle adapted to receive a removable lead indicator in accordance with an embodiment of the present disclosure.

FIG. 5 is a schematic illustration of a removable lead indicator on an epidural needle during implantation of a therapy delivery element in accordance with an embodiment of the present disclosure.

FIG. 6 is a perspective view of a removable lead indicator suitable for attachment to an epidural needles in accordance with an embodiment of the present disclosure.

FIG. 7 is a side sectional view of the lead indicator of FIG. 6.

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FIG. 8 is a perspective view of an alternate removable lead indicator in accordance with an embodiment of the present disclosure.

FIG. 9 is a side view of a clip having lead indicators adapted to attach to therapy delivery elements in accordance with an embodiment of the present disclosure.

FIG. 10 is a perspective view of a stylet-lead assembly in accordance with an embodiment of the present disclosure.

FIG. 11 is a perspective view of a trial cable connector with lead indicators in accordance with an embodiment of the present disclosure.

FIG. 12 is a perspective view of a removable lead indicator adapted for insertion into a lumen of a therapy delivery element in accordance with an embodiment of the present disclosure.

FIG. 13 illustrates a method of using a lead identification system in accordance with an embodiment of the present disclosure.

FIG. 14 is a flow chart summarizing a method for implanting a plurality of trial leads using a lead identification system in accordance with an embodiment of the present disclosure.

FIGS. 15A and 15B are flow charts summarizing a method for implanting a plurality of permanent leads using a lead identification system in accordance with an embodiment of the present disclosure.

FIGS. 16A and 16B are flow charts summarizing a method for implanting a plurality of permanent leads with trial lead extensions using a lead identification system in accordance with an embodiment of the present disclosure.

FIG. 16C is a flow chart summarizing a method of implanting a plurality of permanent leads, with or without permanent lead extensions, using a lead identification system in accordance with an embodiment of the present disclosure.

DETAILED DESCRIPTION OF SOME EMBODIMENTS

The description that follows relates to a spinal cord stimulation (SCS) system. However, it is to be understood that while the present disclosure lends itself well to applications in SCS, the disclosure in its broadest aspects may not be so limited. Rather, the disclosure may be used with any type of implantable therapy delivery system with one or more therapy delivery elements. For example, the present disclosure may be used as part of a pacemaker, a defibrillator, a cochlear stimulator, a retinal stimulator, a stimulator configured to produce coordinated limb movement, a cortical stimulator, a deep brain stimulator, peripheral nerve stimulator, microstimulator, or in any other neural stimulator configured to treat urinary incontinence, sleep apnea, shoulder subluxation, headache, etc.

In another embodiment, one or more of the therapy delivery elements may be a fluid delivery conduit, such as a catheter, including an inner lumen that is placed to deliver a fluid, such as pharmaceutical agents, insulin, pain relieving agents, gene therapy agents, or the like from a fluid delivery device (e.g., a fluid reservoir and/or pump) to a respective target tissue site in a patient.

In yet another embodiment, one or more of the therapy delivery elements may be an electrical lead including one or more sensing electrodes to sense physiological parameters (e.g., blood pressure, temperature, cardiac activity, etc.) at a target tissue site within a patient. In the various embodiments contemplated by this disclosure, therapy may include stimulation therapy, sensing or monitoring of one or more physiological parameters, fluid delivery, and the like. "Therapy delivery element" includes pacing or defibrillation leads,

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stimulation leads, sensing leads, fluid delivery conduit, and any combination thereof "Target tissue site" refers generally to the target site for implantation of a therapy delivery element, regardless of the type of therapy.

FIG. 1 illustrates a generalized therapy delivery system 10 that may be used in spinal cord stimulation (SCS), as well as other stimulation applications. The therapy delivery system 10 generally includes an implantable pulse generator 12 ("IPG") ("IPG"), an implantable therapy delivery element 14, which carries an array of electrodes 18 (shown exaggerated for purposes of illustration), and an optional implantable extension lead 16. Although only one therapy delivery element 14 is shown, typically two or more therapy delivery elements 14 are used with the therapy delivery system 10.

The therapy delivery element 14 includes elongated body 40 having a proximal end 36 and a distal end 44. The elongated body 40 typically has a diameter of between about 0.03 inches to 0.07 inches and a length within the range of 30 cm to 90 cm for spinal cord stimulation applications. The elongated body 40 may be composed of a suitable electrically insulative material, such as, a polymer (e.g., polyurethane or silicone), and may be co-extruded with the conductors.

In the illustrated embodiment, proximal end 36 of the therapy delivery element 14 is electrically coupled to distal end 38 of the extension lead 16 via a connector 20, typically associated with the extension lead 16. Proximal end 42 of the extension lead 16 is electrically coupled to the implantable pulse generator 12 via connector 22 associated with housing 28. Alternatively, the proximal end 36 of the therapy delivery element 14 can be electrically coupled directly to the connector 22.

In the illustrated embodiment, the implantable pulse generator 12 includes electronic subassembly 24 (shown schematically), which includes control and pulse generation circuitry (not shown) for delivering electrical stimulation energy to the electrodes 18 of the therapy delivery element 14 in a controlled manner, and a power supply, such as battery 26.

The implantable pulse generator 12 provides a programmable stimulation signal (e.g., in the form of electrical pulses or substantially continuous-time signals) that is delivered to target stimulation sites by electrodes 18. In applications with more than one therapy delivery element 14, the implantable pulse generator 12 may provide the same or a different signal to the electrodes 18.

Alternatively, the implantable pulse generator 12 can take the form of an implantable receiver-stimulator in which the power source for powering the implanted receiver, as well as control circuitry to command the receiver-stimulator, are contained in an external controller inductively coupled to the receiver-stimulator via an electromagnetic link. In another embodiment, the implantable pulse generator 12 can take the form of an external trial stimulator (ETS), which has similar pulse generation circuitry as an IPG, but differs in that it is a non-implantable device that is used on a trial basis after the therapy delivery element 14 has been implanted and prior to implantation of the IPG, to test the responsiveness of the stimulation that is to be provided.

The housing 28 is composed of a biocompatible material, such as for example titanium, and forms a hermetically sealed compartment containing the electronic subassembly 24 and battery 26 protected from the body tissue and fluids. The connector 22 is disposed in a portion of the housing 28 that is, at least initially, not sealed. The connector 22 carries a plurality of contacts that electrically couple with respective terminals at proximal ends of the therapy delivery element 14 or extension lead 16. Electrical conductors extend from the connector 22 and connect to the electronic subassembly 24.

FIG. 2 illustrates the therapy delivery element 14 implanted in the epidural space 30 of a patient in close proximity to the dura, the outer layer that surrounds the spinal cord 32, to deliver the intended therapeutic effects of spinal cord electrical stimulation. The target stimulation sites may be anywhere along the spinal cord 32, such as for example proximate the sacral nerves.

Because of the lack of space near the lead exit point 34 where the therapy delivery element 14 exits the spinal column, the implantable pulse generator 12 is generally implanted in a surgically-made pocket either in the abdomen or above the buttocks, such as illustrated in FIG. 3. The implantable pulse generator 12 may, of course, also be implanted in other locations of the patient's body. Use of the extension lead 16 facilitates locating the implantable pulse generator 12 away from the lead exit point 34. In some embodiments, the extension lead 16 serves as a lead adapter if the proximal end 36 of the therapy delivery element 14 is not compatible with the connector 22 of the implantable pulse generator 12, since different manufacturers use different connectors at the ends of their stimulation leads and are not always compatible with the connector 22.

As illustrated in FIG. 3, the therapy delivery system 10 also may include a clinician programmer 46 and a patient programmer 48. Clinician programmer 46 may be a handheld computing device that permits a clinician to program neurostimulation therapy for patient using input keys and a display. For example, using clinician programmer 46, the clinician may specify neurostimulation parameters for use in delivery of neurostimulation therapy. Clinician programmer 46 supports telemetry (e.g., radio frequency telemetry) with the implantable pulse generator 12 to download neurostimulation parameters and, optionally, upload operational or physiological data stored by implantable pulse generator 12. In this manner, the clinician may periodically interrogate the implantable pulse generator 12 to evaluate efficacy and, if necessary, modify the stimulation parameters.

Similar to clinician programmer 46, patient programmer 48 may be a handheld computing device. Patient programmer 48 may also include a display and input keys to allow patient to interact with patient programmer 48 and the implantable pulse generator 12. The patient programmer 48 provides patient with an interface for control of neurostimulation therapy provided by the implantable pulse generator 12. For example, patient may use patient programmer 48 to start, stop or adjust neurostimulation therapy. In particular, patient programmer 48 may permit patient to adjust stimulation parameters such as duration, amplitude, pulse width and pulse rate, within an adjustment range specified by the clinician via clinician programmer 46, or select from a library of stored stimulation therapy programs.

The implantable pulse generator 12, clinician programmer 46, and patient programmer 48 may communicate via cables or a wireless communication. Clinician programmer 46 and patient programmer 48 may, for example, communicate via wireless communication with the implantable pulse generator 12 using RF telemetry techniques known in the art. Clinician programmer 46 and patient programmer 48 also may communicate with each other using any of a variety of local wireless communication techniques, such as RF communication according to the 802.11 or Bluetooth specification sets, infrared communication, e.g., according to the IrDA standard, or other standard or proprietary telemetry protocols.

FIG. 3 also illustrates a general environment that may benefit from use of a tunneling tool in accordance with an embodiment of the present disclosure. Since the implantable pulse generator 12 is located remotely from target location 50

for therapy, the therapy delivery element 14 and/or the extension lead 16 is typically routed through a pathway 52 subcutaneously formed along the torso of the patient to a subcutaneous pocket 54 where the implantable pulse generator 12 is located. As used hereinafter, "lead" and "lead extension" are used interchangeably, unless content clearly dictates otherwise.

The therapy delivery elements 14 are typically fixed in place near the location selected by the clinician using the present suture anchors 60. The suture anchors 60 can be positioned on the therapy delivery element 14 in a wide variety of locations and orientations to accommodate individual anatomical differences and the preferences of the clinician. The suture anchors 60 may then be affixed to tissue using fasteners, such as for example, one or more sutures, staples, screws, or other fixation devices. The tissue to which the suture anchors 60 are affixed may include subcutaneous fascia layer, bone, or some other type of tissue. Securing the suture anchors 60 to tissue in this manner prevents or reduces the chance that the therapy delivery element 14 will become dislodged or will migrate in an undesired manner.

FIG. 4 illustrates an epidural needle 70 configured to permit therapy delivery element 78 to be advanced into, and withdrawn from, an epidural space 72 (see FIG. 5) in accordance with an embodiment of the present disclosure. The epidural needle 70 includes an outer cannula 74 and an inner cannula 76. Removal of the inner cannula 76 creates an opening sized to receive a therapy delivery element 78. An epidural needle suitable for implanting the therapy delivery element 78 is disclosed in commonly-assigned U.S. patent application Ser. No. 13/046,282, entitled Epidural Needle for Spinal Cord Stimulation, filed Mar. 11, 2011, which is hereby incorporated by reference.

FIG. 5 is a schematic illustration of the epidural needle 70 located in the epidural space 72 between the L1 and T12 vertebrae. The therapy delivery element 78 is inserted through the epidural needle 70 and positioned in the epidural space 72 of the patient. Lead indicator 82 is attached to hub 84 of the epidural needle 70. The lead indicator 82 can also be attached to the needle portion 70.

In one embodiment, the lead indicators 82 for the present lead identification system are color coded. Any color scheme can be used. One approach is the red-yellow-green color scheme used for traffic lights throughout the world, where the red light is always on the top and the green on the bottom. A similar color scheme can be used on the trial cable and the connector block on the IPG 12 so the colors also have a fixed spatial relationship.

In another embodiment, the indicators 82 include both a color scheme and tactile indicators so the surgeon can identify the indicators both visually and by feel. For example, the lead indicators can have different textures (e.g., smooth-textured-rough surface finish) or a unique shape (e.g., circle-square-triangle) that correspond to the red-yellow-green color scheme. In yet another embodiment, the indicators include alpha-numeric characters. While the present lead indicators are preferably color coded, reference to a lead indicator should be understood to include a variety of indicators for use in the present lead identification system.

FIGS. 6 and 7 illustrate an embodiment of a removable lead indicator 82 suitable for attachment to the hub 84 of the epidural needles 70 in accordance with an embodiment of the present disclosure. The removable lead indicator 82 includes slot 86 that permits it to engage with outer cannula 74 illustrated in FIG. 4. In one embodiment, the lead indicator 82 includes internal threads 88 that are configured to engage

external threads **90** on the hubs **84**. Alternatively, the lead indicator **82** can be snap-fit onto narrow portion **96** of the hubs **84**.

In one embodiment, the lead indicators **82** are different colors (e.g., red-yellow-green). In another embodiment, outer surface **83** includes different sized recesses **85** corresponding to the red-yellow-green lead indicators **82**. In yet another embodiment, alpha-numeric indicators **87** can be added to the lead indicator **82**. The different colors, alpha-numeric indicators, and recesses **85** can be used separately or in combination in accordance with the present lead identification system.

In another embodiment best illustrated in FIG. 4, an elastomeric sleeve **97** is positioned in the narrow portion **96**. The sleeve **97** includes indicia, such as for example different color strips. By rotating the sleeve **97** the surgeon can align the indicia marker **99** on the hub **84**. Epidural needles **70** with rotating sleeves **97** can be configured to identify any of the therapy delivery elements **78**.

FIG. 8 illustrates an alternate removable lead indicator **92** suitable for attachment to the epidural needle **70** of FIG. 4. Flexible arms **94A**, **94B** elastically deform to permit engagement with the outer cannula **74** and/or the hub **84**. The lead indicators can include a variety of indicia, such as color-coding. In the illustrated embodiment, the lead indicator **92** also includes an identifying texture **98**. For example, the lead indicators **92** can include smooth-textured-rough surfaces **98** used as part of the present lead identification system.

FIG. 9 illustrates a clip **102** adapted to attach proximal ends **100** of the therapy delivery elements **78** to the patient in accordance with an embodiment of the present disclosure. The proximal ends **100** of the therapy delivery elements **78** are preferably clipped or otherwise attached to the patient or surgical drape during various phases of the implantation process. In the illustrated embodiment, the clip **102** includes three discrete receiving openings **104A**, **104B**, **104C** (“**104**”) sized to receive proximal ends **100** of three therapy delivery elements **78**. Each receiving opening **104** includes a slot **106** to permit insertion of the therapy delivery element **78** and a lead indicator **108A**, **108B**, **108C** (“**108**”), such as for example color-coded inserts. In one embodiment, the clip **102** is constructed from an elastomeric material. By bending the clip **102** in the direction **110**, the size of the slots **106** increases to facilitate engagement of the therapy delivery elements **78**. The clip **102** can be attached using clamps, adhesive tape, or a variety of other techniques.

FIG. 10 illustrates one possible embodiment of the therapy delivery element **78** for use with the present lead identification system. Stylet handle **122** is attached to a stylet wire that extends through lumen **142** (see FIG. 12) of the therapy delivery element **78**. In the illustrated embodiment, the stylet handle **122** covers one or more of the contacts **124** at proximal end **126** of the therapy delivery element **78**. The stylet handle **122** is preferably detached from the therapy delivery element **78** and moved in direction **128** a sufficient amount to expose all of the contacts **124**. Each contact **124** has a corresponding electrode **125** at the distal end **127** of the therapy delivery element **78**.

As illustrated in FIG. 11, the exposed contacts **124** on the proximal ends **126** are then attached to connector blocks **130A**, **130B**, **130C**, **130D**, **130E** (“**130**”) on trial cable connector **132**. In the illustrated embodiment, trial cable connector **132** includes three eight contact connector blocks **130A**, **130B**, **130C** and two twelve contact connector blocks **130D**, **130E**. Trial stimulation of the therapy delivery elements **78** is then conducted as is known by those of skill in the art. The connector blocks **130** include lead indicators **134**, such as for example, color coding, alpha-numeric symbols, geometric

shapes, and a variety of other lead indicators to identify the particular connector blocks **130**.

Once the surgeon has confirmed that the therapy delivery elements **78** are located in the desired location within the epidural space **72**, the stylet handle **122** and the attached stylet are removed. As illustrated in FIG. 12, removable lead indicators **140** are inserted in the lumen **142** at proximal end **126** of each therapy delivery element **78**. In the illustrated embodiment, the removable lead indicators **140** each include a stylet wire **144** and a color indicator **146**. The color indicators **146** preferably have a diameter less than or equal to the diameter of the therapy delivery element **78**. In one embodiment, color indicators **146** are colored silicone tubing that compressively engages with the stylet wire **144**. A clear shrink wrap is optionally applied over the silicone tubing.

The stylet wires **144** optionally include bends **148** to increase friction with the lumen **142**. The bends **148** reduce the chance of the removable lead indicator **140** from inadvertently falling out of the lumens **142**.

After a removable lead indicator **140** is inserted in each lumen **142**, the therapy delivery elements **78** are disconnected from the trial cable connector **132**. At this point, the proximal ends **126** of the therapy delivery elements **78** are free and the epidural needles **70** can be removed from the patient and slid off the proximal ends **126**. The therapy delivery elements **78** will typically need to be temporarily disconnected from the clip **102** to remove the epidural needles **70**.

The present lead identification system provides corresponding lead indicators **82**, **92**, **102**, **134**, **140**, and **150** that permit the surgeon to track the electrodes **125** of a particular therapy delivery element **78** to the correct connectors **124** on the implantable pulse generator **12**. Since the lead indicators **82**, **92**, **102**, **134**, **140**, and **150** are releasably attachable to the components of the neurostimulation system, they can be shifted or reconfigured by the surgeon during the procedure. For example, two therapy delivery elements switch position during placement, or test stimulation shows the midline to be offset from its anticipated location. The lead indicators are easily reconfigured during the procedure to reflect the actual lead placement. As a result, the components of the neurostimulation system, such as the epidural needles, the leads and lead extensions, lead clips, lead anchors, stylets, internal and external pulse generators, and trial cables can be generic without any labels or indicia. The use of removable lead indicators dramatically reduces the inventory of components for the neurostimulation system. As used herein, “corresponding lead indicator” refers to a lead indicator with indicia that can be correlated with indicia on at least one other lead indicator.

As illustrated in FIG. 13, each therapy delivery element **78** are attached to the patient with an anchor **150** that preferably includes a lead indicator in accordance with an embodiment of the present disclosure. In one embodiment, the anchors **150** are color coded to identify the individual therapy delivery elements **78**. Suitable anchors **150** are disclosed in commonly-assigned U.S. patent application Ser. Nos. 13/045,874, entitled Anchor for Implantable Medical Device, filed Mar. 11, 2011; 13/045,947, entitled Anchor Sleeve for Implantable Sleeve, filed Mar. 11, 2011; and 13/046,182, entitled Pre-Sutured Anchor for Implantable Leads, filed Mar. 11, 2011, all of which are hereby incorporated by reference.

The surgeon then creates a pathway **152** between the incision site **154** near the anchors **150** and the incision site **156** for the subcutaneous pocket **54** holding the implantable pulse generator **12** (see FIG. 3). The pathway **152** is preferably created using a tunneling tool, such as disclosed in commonly-assigned U.S. patent application Ser. No. 13/046,144,

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entitled Tunneling Tool for Implantable Leads, filed Mar. 11, 2011, which is hereby incorporated by reference.

After the tunneling step is completed, sheath 160 extends along the pathway 152. Proximal ends 126 of the therapy delivery elements 78 are passed through lumen 162 in the sheath 160 to the incision site 156. The sheath 160 is then removed from the patient by pulling it through the incision site 156 so that the therapy delivery elements 78 extend through the pathway 152 and out the incision site 156. The lead indicators 140 are then removed from the lumens 142 at the proximal ends 126 of the therapy delivery elements 78. Each therapy delivery element 78 is attached to a corresponding connector 22 on the implantable pulse generator 12. The connectors 22 are preferably color coded. The implantable pulse generator 12 is implanted in the subcutaneous pocket 54 and the incision sites 154, 156 closed.

As will be discussed in detail below, the present method can be used for implanting trial leads or permanent leads, using a variety of procedures. While the following flow charts use color coded lead indicators, it will be appreciated that a wide variety of other indicators can be used with the methods of the present lead identification system.

FIG. 14 is a flow chart summarizing a method for implanting a plurality of trial leads using a lead identification system in accordance with an embodiment of the present disclosure. An epidural needle is inserted into the patient for each trial lead (200). The stylets are removed from the epidural needles (202). The trial leads are inserted through each epidural needle and positioned in the patient (204). A lead indicator is attached to each epidural needle (206). Proximal portions of the trial leads are preferably clipped to the patient using a clip with a lead indicator (208). The stylets are partially removed from each of the trial leads to expose the contacts (210). The contacts at the proximal ends of the trial leads are electrically coupled to color coded connectors on a trial cable (212). Trial stimulation of the trial leads is conducted to confirm lead placement (214). The stylets are removed from each of the trial leads (216) and color coded stylets are inserted in each of the trial lead lumens (218). The trial leads are then disconnected from the trial cable (220). The epidural needles are slid off the trial lead and are removed from the patient. The incision(s) around the trial leads are closed (222). The trial leads are electrically coupled to connectors on the external pulse generator used for home trials and the exposed portions of the trial leads and the external pulse generator are attached to the patient for the home trial (224). After the home trial is completed, the trial leads are removed from the patient (226).

FIGS. 15A and 15B are flow charts summarizing a method for implanting a plurality of permanent leads using a lead identification system in accordance with an embodiment of the present disclosure. An epidural needle is inserted into the patient for each permanent lead (250). The stylets are removed from the epidural needles (252). The permanent leads are inserted through each epidural needle and positioned in the patient (254). A different color indicator is attached to each epidural needle (256). The permanent leads are preferably clipped to the patient using a color coded clip (258). The stylets are partially removed from each of the permanent leads to expose the contacts (260). The proximal ends of the permanent leads are electrically coupled to color coded connectors on a trial cable (262). Trial stimulation of the permanent leads is conducted to confirm lead placement (264). The permanent leads are disconnected from the trial cable (266). The stylets are removed from each of the permanent leads (268) and color coded stylets are inserted in each of the permanent lead lumens (270).

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The epidural needles are slid off the permanent leads and removed from the patient (272). The permanent leads are attached to the patient using color coded anchors (274). A passageway is tunneled to the IPG site (276). Proximal ends of the permanent leads are passed through a lumen in the tunneling sheath (278). The color coded stylets are removed from the proximal ends of the permanent leads (280). The proximal ends of the permanent leads are then electrically coupled to corresponding color coded connectors on the IPG (282). The IPG is implanted and the incision sites are closed (284).

FIGS. 16A and 16B are flow charts summarizing a method for implanting a plurality of permanent leads with trial lead extensions using a lead identification system in accordance with an embodiment of the present disclosure. An epidural needle is inserted into the patient for each permanent lead (300). The stylets are removed from the epidural needles (302). The permanent leads are inserted through each epidural needle and positioned in the patient (304). A different color indicator is attached to each epidural needle (306). The permanent leads are preferably clipped to the patient using a color coded clip (308). The stylets are partially removed from each of the permanent leads to expose the contacts (310). The proximal ends of the permanent leads are electrically coupled to color coded connectors on a trial cable (312). Trial stimulation of the permanent leads is conducted to confirm lead placement (314). The stylets are removed from each of the permanent leads (316) and color coded stylets are inserted in each of the permanent lead lumens (318). The permanent leads are disconnected from the trial cable (320). The epidural needles are removed from the patient and slid off the permanent leads (322). The permanent leads are attached to the patient using color coded anchors (324). The color coded stylets are transferred from the permanent leads to proximal ends of trial lead extensions (326).

Distal ends of the trial lead extensions are connected to color coded proximal ends of the permanent leads (328). A passageway is tunneled to the IPG site (330). Proximal ends of the trial lead extensions are passed through a lumen in the tunneling sheath (332). The color coded stylets are removed from the proximal ends of the trial lead extensions (334). The proximal ends of the trial lead extensions are then electrically coupled to corresponding color coded connectors on the trial cable (336). The incision sites are closed (338). The trial pulse generator and trial cable are attached to the patient for home trial (340).

FIG. 16C is a flow chart summarizing a method for implanting a plurality of permanent leads, with or without permanent lead extensions, using a lead identification system in accordance with an embodiment of the present disclosure. The incision site where the trial lead extensions are connected to the permanent leads is opened (350). The trial lead extensions are disconnected from the permanent leads (352). Color coded stylets are inserted into proximal ends of the permanent leads (354). The connectors on the trial lead extensions are cut-off and removed from the patient (356). The proximal ends of the trial lead extensions are pulled to remove from the patient (358). A passageway is tunneled to the IPG site (360). If the permanent leads are not long enough to reach the IPG site, permanent lead extensions are attached to the permanent leads (262). Color coded stylets are inserted in the proximal ends of the permanent leads (or the proximal ends of the permanent lead extensions) (264). The proximal ends of the permanent leads (or the permanent lead extensions) are passed through the tunneling sheath, and the tunneling sheath is removed (366). The color coded stylets are removed from the proximal ends of the permanent leads (or the permanent

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lead extensions) (368). The proximal ends of the permanent leads (or the permanent lead extensions) are electrically coupled to corresponding color coded connectors on the IPG (370). The IPG is implanted and the incisions are closed (372).

Where a range of values is provided, it is understood that each intervening value, to the tenth of the unit of the lower limit unless the context clearly dictates otherwise, between the upper and lower limit of that range and any other stated or intervening value in that stated range is encompassed within this disclosure. The upper and lower limits of these smaller ranges which may independently be included in the smaller ranges is also encompassed within the disclosure, subject to any specifically excluded limit in the stated range. Where the stated range includes one or both of the limits, ranges excluding either both of those included limits are also included in the disclosure.

Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this disclosure belongs. Although any methods and materials similar or equivalent to those described herein can also be used in the practice or testing of the various methods and materials are now described. All patents and publications mentioned herein, including those cited in the Background of the application, are hereby incorporated by reference to disclose and described the methods and/or materials in connection with which the publications are cited.

The publications discussed herein are provided solely for their disclosure prior to the filing date of the present application. Nothing herein is to be construed as an admission that the present disclosure is not entitled to antedate such publication by virtue of prior invention. Further, the dates of publication provided may be different from the actual publication dates which may need to be independently confirmed.

Other embodiments are possible. Although the description above contains much specificity, these should not be construed as limiting the scope of the disclosure, but as merely providing illustrations of some of the presently preferred embodiments. It is also contemplated that various combinations or sub-combinations of the specific features and aspects of the embodiments may be made and still fall within the scope of this disclosure. It should be understood that various features and aspects of the disclosed embodiments can be combined with or substituted for one another in order to form varying modes disclosed. Thus, it is intended that the scope of at least some of the present disclosure should not be limited by the particular disclosed embodiments described above.

Thus the scope of this disclosure should be determined by the appended claims and their legal equivalents. Therefore, it will be appreciated that the scope of the present disclosure fully encompasses other embodiments which may become obvious to those skilled in the art, and that the scope of the present disclosure is accordingly to be limited by nothing other than the appended claims, in which reference to an element in the singular is not intended to mean "one and only one" unless explicitly so stated, but rather "one or more." All structural, chemical, and functional equivalents to the elements of the above-described preferred embodiment that are known to those of ordinary skill in the art are expressly incorporated herein by reference and are intended to be encompassed by the present claims. Moreover, it is not necessary for a device or method to address each and every problem sought to be solved by the present disclosure, for it to be encompassed by the present claims. Furthermore, no element, component, or method step in the present disclosure is

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intended to be dedicated to the public regardless of whether the element, component, or method step is explicitly recited in the claims.

What is claimed is:

1. A neurostimulation system comprising:

a plurality of therapy delivery elements each comprising a proximal end with a plurality of electrical contacts adapted to electrically couple with an implantable pulse generator and a distal end with a plurality of electrodes electrically coupled to the electrical contacts, each of the plurality of therapy delivery elements being configured to be implanted using one of a plurality of epidural needles;

a plurality of removable lead indicators each adapted to attach to one of the plurality of epidural needles to uniquely identify each of the therapy delivery elements; at least one clip with corresponding lead indicators adapted to releasably attach to proximal ends of the therapy delivery elements;

a trial cable having connectors with corresponding lead indicators adapted to conduct trial stimulation of the therapy delivery elements;

a plurality of removable lead indicator stylets adapted to be inserted into lumens at proximal ends of each of the therapy delivery elements; and

a pulse generator with connectors having corresponding lead indicators, where the lead indicators permit a surgeon to track electrodes on a particular therapy delivery element to a corresponding connector on the implantable pulse generator.

2. The neurostimulation system of claim 1, wherein each of the lead indicators comprises one or more of color indicators, tactile indicators, alpha-numeric indicators, or a combination thereof.

3. The neurostimulation system of claim 1, wherein the therapy delivery elements comprise one of trial leads or permanent leads.

4. The neurostimulation system of claim 1, wherein the pulse generator comprises one of an external pulse generator for conducting trials or an implantable pulse generator.

5. The lead identification neurostimulation system of claim 1, comprising one or more lead anchors with corresponding lead indicators adapted to attach the therapy delivery elements to the patient.

6. The neurostimulation system of claim 1, wherein the lead indicator stylets comprise a diameter less than, or equal to, a diameter of the therapy delivery elements.

7. The neurostimulation system of claim 1, comprising rotating lead indicators attached to each of the epidural needles, wherein a rotational orientation of the rotating lead indicators uniquely identify each of the therapy delivery elements.

8. A lead identification system for tracking a plurality of therapy delivery elements during implantation in a patient using a plurality of epidural needles to corresponding connectors on an implantable pulse generator, each of the plurality of therapy delivery elements being configured to be implanted using one of the plurality of epidural needles, the lead identification system comprising:

a plurality of removable lead indicators each adapted to attach to one of the plurality of epidural needles to uniquely identify each of the therapy delivery elements;

at least one clip with corresponding lead indicators adapted to releasably attach to proximal ends of the therapy delivery elements; and

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a plurality of removable lead indicator stylets adapted to be inserted into lumens at proximal ends of each of the therapy delivery elements.

9. The lead identification system of claim 8, comprising at least one clip with corresponding lead indicators adapted to releasably attach to proximal ends of the therapy delivery elements.

10. The lead identification system of claim 8, comprising a trial cable having connectors with corresponding lead indicators adapted to conduct trial stimulation of the therapy delivery elements.

11. The lead identification system of claim 8, comprising a pulse generator with connectors having corresponding lead indicators.

12. The lead identification system of claim 8, wherein the lead indicator stylets comprise a diameter less than, or equal to, a diameter of the therapy delivery elements.

13. The lead identification system of claim 8, comprising rotating lead indicators attachable to each of the epidural needles, wherein a rotational orientation of the rotating lead indicators uniquely identify each of the therapy delivery elements.

14. A lead identification system for tracking at least two therapy delivery elements during implantation in a patient, each of the therapy delivery elements being configured to be implanted using one of at least two epidural needles, the lead identification system comprising:

at least two removable lead indicators, each removable lead indicator adapted to attach to one of the epidural needles to uniquely identify each of the therapy delivery elements;

at least one clip with at least two clip lead indicators corresponding to the at least two removable lead indicators, the clip lead indicators adapted to releasably attach to proximal ends of the therapy delivery elements; and

at least two removable lead indicator stylets corresponding to the at least two removable lead indicators, each removable lead indicator stylet adapted to be inserted into a lumen at a proximal end of each of the therapy delivery elements.

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15. The lead identification system of claim 14, wherein each of the removable lead indicators includes a color indicator, the color indicators of each of the removable lead indicators being different from one another.

16. The lead identification system of claim 14, wherein each of the removable lead indicators includes a tactile indicator, the tactile indicators of each of the removable lead indicators being different from one another.

17. The lead identification system of claim 14, wherein each of the removable lead indicators includes an alpha-numeric indicator, the alpha-numeric indicators of each of the removable lead indicators being different from one another.

18. The lead identification system of claim 14, wherein the lead indicator stylets include a diameter less than a diameter of the therapy delivery elements.

19. The lead identification system of claim 14, comprising rotating lead indicators attachable to each of the epidural needles, wherein a rotational orientation of the rotating lead indicators uniquely identify each of the therapy delivery elements.

20. The lead identification system of claim 14, comprising a trial cable configured to conduct trial stimulation of the therapy delivery elements, the trial cable including at least two connectors including at least two connector lead indicators corresponding to the at least two removable lead indicators.

21. The lead identification system of claim 14, comprising a pulse generator including at least two connectors including at least two connector lead indicators corresponding to the at least two removable lead indicators.

22. The lead identification system of claim 14, comprising at least two lead anchors configured to attach the therapy delivery elements to the patient, the lead anchors including at least two anchor lead indicators corresponding to the at least two removable lead indicators.

23. The lead identification system of claim 14, wherein the therapy delivery elements include trial leads.

24. The lead identification system of claim 14, wherein the therapy delivery elements include permanent leads.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 8,473,074 B2
APPLICATION NO. : 13/222330
DATED : June 25, 2013
INVENTOR(S) : Richard North et al.

Page 1 of 1

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the Claims

Column 14, line 43 (Claim 5, line 1) after “The” delete “lead identification”

Column 14, line 51 (Claim 7, line 2) after “indicators” delete “attach”

Signed and Sealed this
Twenty-seventh Day of May, 2014



Michelle K. Lee
Deputy Director of the United States Patent and Trademark Office